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VIEW OF THE VOLCANO OF AGUA FROM A NEIGHBORING TOWN

RUINS OF CHURCHES AND PALACES OF ANTIGUA. DESTRUCTION WROUGHT BY THE VOLCANO OF AGUA

ANTIGUA—A CENTRAL AMERICAN CITY WITH A WONDERFUL PAST—[SEE PAGE 231]

The Formation, Growth, and Habit of Crystals*

Modern Views of Crystallography

By Paul Gaubert, D. Sc, Assistant in Mineralogy at the Natural History Museum, Paris

A crystal arouses the interest of the observer not only by the regularity of its forms, the perfection of its surfaces and angles, its transparency, and its brilliancy, but also by the manner in which it grows, heals its wounds, is dissolved, and modified under the influence of the inclosing medium. To some authors the crystal, from certain points of view, appears analogous to living forms, and seems to undergo a sort of evolution.

Its formation, its growth, the variations of the faces under the influence of the inclosing medium, have been the object of numerous researches which have greatly modified our conceptions regarding them. The purpose of this article is to show the present state of our knowledge concerning these diverse and interesting questions of crystallogeny.

I.

As early as the seventeenth century Leeuwenhoek, who examined under the microscope everything that in his time lent itself to this line of observation, followed the formation and growth of the crystals of various substances (as sugar, tartar, sea salt, etc.). He was led to conclude that the cubic crystals of sea salt are formed of other minute cubes, themselves made up from cubes, the existence of which one has to accept through analogy with what is seen, since they are invisible under any magnifying power. Later, Baker, Ledermüller, and others also examined under the microscope the branched and varied forms that appear when a substance crystallizes on a sheet of glass; but it is to Nicholas Le Blanc that we owe the first systematic and effective researches in crystal genesis, and particularly in the variation of the form. In his very interesting work, "De la Cristallotechnie," he gives methods for the preparation of crystals, and in particular does he set forth the process of renewing the solution, of "feeding" the growing solids that they may attain a relatively considerable size.

In what form do we see the crystal with the aid of the highest magnifying power? Does it present from the first the form that it will have later? The biologists were the first to take up the matter of the formation of the crystalline "germ"; that is, of the form which it presents at the instant when it first becomes visible; and most of them have admitted the existence of an embryonic state, or a state in which the constitution and form are different from that of the crystal properly called; although this idea has been contradicted by Frankenheim, to whom we owe numerous crystallogenic observations. Vogelsang, in 1867, took it up again and made numerous ingenious and varied experiments to show its correctness. His observations are generally exact, but he has unfortunately misinterpreted them. To show the embryonic state of the crystal, Vogelsang tried to make the bodies crystallize under special conditions with the purpose of retarding their formation so as to enable him to observe all the steps of development. With this purpose in view he added to sulphur solution a viscous body, Canada balsam. There were produced little spheres, to which Vogelsang gave the name of globulites, and which were thought to represent an embryonic stage. These globulites unite to form particular groups, each of which has received a special name, and at the expense of which the crystal would be produced only at a later stage.

Moreover, Vogelsang rests his experimental researches on observations made with crystallites of varied forms existing in a few rocks rich in silica and more or less vitreous, and in the slags of blast furnaces; but as was later shown by M. O. Lehmann, who made numerous researches on the formation of crystals, these globulites are but drops supersaturated with sulphur, and consequently have nothing in common with the crystalline state.

Brame, as well as Vogelsang, studied sulphur, but in a molten condition. He observed little supermelted drops (utricules) to which he attributes a considerable role in crystallization. His ideas differ from those of Vogelsang, but nothing in his experiments substantiates the existence of an embryonic state.

The observations of M. O. Lehmann have shown that the crystal possesses from the beginning a form identical with that which it has when it has attained larger dimensions. T. V. Richard and E. H. Archibald have employed the cinematograph to follow out the formation of the crystal, and obtained only figures of completely formed individuals.

I myself have made a great many experiments, and have always found that the first visible particle had all the properties of the crystal. It is, nevertheless, not to be disputed that in some cases there takes place what Vogelsang and his predecessors have observed with sulphur or other bodies, but who worked with supersaturated drops or amorphous particles, or little spherulites of unstable form, which later underwent modifications into more stable forms, and the normal development of which can then be followed.

Nevertheless, in spite of the observations of Frankenheim, O. Lehmann, and others, the idea of the embryonic state of the crystal has not disappeared from science, and the hypothesis of Vogelsang, supported by De Schoen, Cartaud, and others, resting on misinterpreted observations, still finds some credit.

II.

When the crystal is once formed—that is, becomes visible under the microscope—how does it grow? Several cases may be presented: First, the mother liquid is in a state of rest, the cooling or evaporation is extremely slow, and the crystalline particles are built up by diffusion alone. In this case the growth is too slow to be constantly followed under the microscope. In the second case the liquid is cooled or evaporated with such rapidity that the quantity of matter deposited on the crystal produces an enlargement microscopically visible. Movements in the liquid are thereby set up. It is an established fact that currents called "currents of concentration" passing over a crystal, deposit a thin coating of substance, followed by a second, and so on, until, for example, one can see on a crystal of lead nitrate, having a diameter of half a millimeter, as many as twelve of these successive layers deposited. If the process were suddenly interrupted and the crystal examined any observed face would not be a plane, but would show a sort of step arrangement, of which the highest step would indicate the point of contact of the current of deposition.

These successive deposits have no interspaces and the crystal may be perfectly transparent. If the crystal of lead nitrate is, however, subjected to the influence of two or of several currents of concentration, the corresponding coatings laid upon it start from different points in the periphery and may not be of the same thickness. Ordinarily they do not join exactly at their point of meeting. In this way are then produced inclusions and the crystal is no longer transparent, but becomes milky. On a glass plate it is easy to produce at will a transparent or milky crystal of lead nitrate. In the experiment it is necessary to agitate the crystal very slightly with a needle in order to subject it to the influence of one or several currents.

These concentration currents produce other peculiarities (vicinal faces, etc.), which it would take too long to describe in detail. I shall confine myself to calling attention to the influence they may have upon the faces of the crystal. The introduction of matter to one face only of a crystal causes it to develop unequally, and since all crystals of the same bath or magma are not influenced in the same way, they may present a number of different forms. The crystals formed at the bottom may be different from those which are deposited on the side walls or at the surface.

III.

If these concentration currents can completely change the habit of a crystal by producing elongation in one direction, the nature of the faces is not modified; an octahedral crystal always appears in octahedrons. But there are two other influences which modify the faces. One of them is the rapidity of crystallization, the other the constant absorption of foreign matter by the crystal in process of growth. Still other factors may intervene, but they are only indirectly concerned.

It has long been known that crystals formed rapidly possess simple faces, while those which have grown slowly are more complicated. Thus in nature the crystals rich in inclusions sometimes of large size, are poor in faces, while the small crystals of the same substance, but transparent, are generally limited by a large number of faces. These differences are due to the rate of crystallization, the influence of which has been known by the experiments of Frankenheim, Lecoq de Bosbaudran, O. Lehmann, and myself In rapid crystallization the crystals have faces with simple symbols; in slow crystallization these same simple faces persist, but the angles and edges have been truncated and beveled, giving rise to new facets, and I have shown that in certain cases these facets make their appearance always in the same order With varying rates of crystallization the dominant forms obtained in the case where the crystallization was rapid persist with more or less extensive development, but it may be otherwise in the case where the faces are modified by the regular absorption by the crystal during the growth of foreign matter added to the mother liquor. This fact is easily made evident, as I have demonstrated, by adding a little coloring matter.

Rome de l'Isle and Berniard have observed that the crystals of sodium chloride formed in urine are regular octahedrons instead of cubes, such as crystallize from a pure mother liquor. Vanquelin and Fourcroy showed later that this curious modification is due to the urea present. Boydant also established a few phenomena of the same class, and tried without success to ascertain why the mere presence of a foreign substance can be thus effective.

P. Curie developed a remarkable and attractive theory, which apparently furnished the key to this curious modification. He claims that the capillary action existing between the liquid and the crystal intervenes, an effect varying with the nature of the faces belonging to the diverse forms and with the nature of the liquid. Basing his belief on Gauss's theory of capillarity, he concludes that such faces develop or require the minimum expenditure of capillary energy. The dominant forms must consequently be conditioned by those faces the constant capillarity of which is the least. The addition of a foreign substance altering the different capillary constants may consequently induce modifications of form.

It appears, indeed, that the capillary forces must act, but up to this time there is no fact known which proves that they intervene sufficiently to modify the forms, in spite of the experiments of M. Berent carried out in the laboratory of Sohncke; moreover, I shall describe later an observation showing that they are without influence.

IV.

The crystals of one substance rarely form synchronously with those of another dissolved in the same mother liquid, and it is on this property that chemists base their action when they attempt to purify bodies by repeated crystallizations; but there are exceptions, as in the well-known coloration of hydrated nitrate of strontium by extract of logwood, which was accomplished by Senarmont. Since then M. Lehmann and I have proved a few other cases of coloration of crystals by artificial organic dyes.

By making use of the artificial coloration of crystals so as to indicate the presence of foreign matter which has crystallized with the colorless substance I have been enabled to show that the absorption caused modification in form.

The absorption of foreign matter by crystals in process of formation is accomplished in two different ways: First, the coloring matter enters into the composition of the crystal, whatever may be its degree of dilution, and is shared between the crystal and the liquid; second, the coloring matter is taken up by the crystal only when the liquid becomes saturated.

The two processes may go on simultaneously. The study of certain properties of colored crystals, particularly polychroism, and the law of division, shows that the coloring substance in the first case is found in the crystal in the same state as in the liquid; in the second, on the contrary, the coloring matter is in the crystalline state, and we have to do then with a regular grouping of the crystalline particles of the colorless substance with those of the coloring material added to the mother liquor.

Lead nitrate is colored by methylene blue in the second manner; it appears in cubic crystals with the triglyphic striæ of pyrite instead of in octahedrons. The modifications in the crystals of this salt produced in a mother liquor which holds methylene blue in solution, show that capillarity does not intervene to produce them. Indeed, in a solution depositing lead nitrate and saturated with methylene blue, without, however, giving crystals of this latter substance, the crystals of the nitrate are not at all modified. They are in octahedrons and colorless, but as soon as the coloring matter begins to crystallize synchronously with them the cube faces appear and finally are formed to the exclusion of all others. Nevertheless, the surface tension can not have been changed since the quantity of methylene blue has remained the same in solution. An interesting fact is the inequality of absorption of the foreign matter dissolved in the mother liquid by the different faces of the crystal. Thus, on the octahedral faces of the lead nitrate the methylene blue is not at all deposited, but only on the faces of the cube and the pentagonal dodecahedron. Similar examples can be cited which explain the ap-

* Translated for the Smithsonian Institution's Annual Report from *Revue Scientifique*, Paris, 48th year, No. 3, January 15th, 1910.

pearance, frequent in minerals, known as hour-glass structure. In the case of cubic crystals, of all the possible faces it is only those which absorb the foreign matter which will develop.

The idea which first comes to mind is that the molecular structure of the crystal plays an important part in this synchronous crystallization. It is not so at all; different foreign substances may be absorbed by different faces, and in such cases the habit of the crystal is dependent on these diverse substances. If one causes the colorless substance to crystallize in a solution containing two colors, each one giving characteristic forms, the crystallizations thus obtained will be the two combined forms, so that one and the same crystal is composed of pyramids or of prisms of different colors. Thus the crystals of urea nitrate colored by methylene blue and picric acid show, if the crystallization has been carefully conducted, yellow triangular prisms corresponding to the faces *g'* and *h'*, and blue triangular prisms corresponding to the prismatic faces *m* of the monoclinic system.

Not only may foreign crystalline matter be absorbed, but also the liquid matter added to the mother liquid, and even the molecules of the latter may also pass regularly into the crystal to modify its form. I have been able to show this fact by crystallizing phthalic acid in a solution containing ethyl alcohol.[1] This explains why a crystal obtained from different solvents may show different faces.

Consequently a crystal, very pure in appearance, transparent, and without inclusions, may contain foreign matter, and in the case where it is the mother liquid which is absorbed its purification is impossible. The solvent must be changed.

When the crystals of a determined substance obtained from two different solutions do not present the same forms, it is incontrovertible that in one of the cases, perhaps in both cases, since we do not always know the form of the pure crystal, there has been absorption of the molecules of the mother liquor. Sometimes it is the water which is absorbed, and this water has been regarded as water of crystallization or as water of constitution, according to the temperature at which it is driven off.

When purification is attempted by recrystallization, if the foreign substance which passes into the crystal is present in small quantities in the mother liquid, the first or the last crystals formed, according to the mode of synchronous crystallization, will be the purest. In case there is a division of the foreign matter between the crystal and the liquid, if the coefficient of its solubility in the crystal and the liquid are known, the number of crystallizations demanded for the purification of the crystals may be calculated under proper conditions.

V.

The natural crystals appear in such varied habits that before Romé de l'Isle no one could see the constancy of forms, and the genius of Hauy was necessary to establish their derivation. It is known that ordinarily the crystals of the same deposit and the same generation are identical, and that those of successive deposits or generations may have different dominant forms. All these differences may be explained by the rapidity of crystallization, but especially by the constant presence of foreign substances. Unfortunately it is difficult to determine the nature of the latter, since the results of analyses made up to the present time have little value in solving this problem. Indeed, a very small quantity of matter is required to modify the forms of a crystal; sometimes an amount even less than one one-thousandth of the weight of the latter is sufficient.

In every case, whether we have to do with natural or artificial crystals, we need to determine their form in the pure state, a form which is constant and which I have called fundamental. It may be distinct from the primitive form chosen by crystallographers.

In closing, I shall observe that the substances prepared in laboratories seem rarely to show the numerous modifications of form, so frequent in the natural crystals. This is due to the fact that the artificial crystals are prepared almost always in the same manner, with the same reagents and consequently with the same foreign substances in the mother liquor. In nature, on the contrary, as the analyses of mineral waters show, the composition of the solutions which deposit the crystals of a given substance varies from one region to another as much in the quality as in the quantity of the different elements dissolved. But all crystals do not lend themselves with the same facility to these modifications of the faces; and just as there exist in nature bodies like calcite which possess the most varied habits, there exist also artificial compounds, the crystals of which may appear in a great number of forms, depending on the condition of crystallization, as, for example, phthalic acid, meconic acid, nitrate and oxalate of urea.

[1] To show this, it is enough to take a colored liquid, but with the exception of bromide there is no liquid which has a proper color at the ordinary temperature.

Lord Morley on Science and Literature

Association with Science as a Literary Asset—The Literary Shortcomings of Scientific Men

An eloquent address on language and literature was delivered on January 27th by Lord Morley of Blackburn, as president of the English Association. Parts of the address dealt with the relation between science and letters, with particular reference to the use of scientific knowledge in poetry, and the antithesis between documentary fact and artistic style. Science aims at concise and truthful expression; and while Lord Morley testified to the value of its influence upon literature, he doubted whether scientific ideas had inspired even Tennyson to the best verse, whether the desire for fact scientifically recorded is not a misfortune in the treatment of modern history, and whether concentration upon scientific truth has not a deadening effect upon emotional conceptions and pleasures.

In commenting on the address, *Nature* remarks: "Lord Morley's tribute to some scientific master of clear and simple exposition resigns us to his subsequent conclusions. Keats could not forgive optics for robbing the rainbow of its wonder and mystery, and Lord Morley seems to suggest that the literary art which deals with scientific studies and results is not of the highest. But poetry is imagery, and new images of Nature are made possible by every discovery of the attributes,and meaning of the things around us. The poetry which neglects advances of natural knowledge becomes conventional in form and substance, concerning itself only with the wonders of childhood because it does not understand the higher and grander mysteries which science has failed to penetrate. History is concerned with the accumulation and consideration of facts with the view of arriving at correct conclusions from them; and in this respect it must be studied by the methods of science, though the human factor makes the problems more difficult than when material things only are involved. There is, however, no intrinsic reason why Gibbon's majesty of historic conceptions and the symmetric grandeur of his design should not be combined with such great learning as was displayed by Lord Acton. Accurate knowledge must surely not be considered as antithetic to perfection of style.

"The instance of Darwin's loss of interest in poetry and music proves little. A wide search through the biographies of distinguished men of science will only reveal two or three cases in which devotion to studies of Nature has resulted in the atrophy of æsthetic faculties. Close concentration upon any particular subject often leads to indifference to the aims and work of others; but this is as true of art, or poetry, or music, as it is of science. There is less reason for believing that the man of science has usually no taste for literature, music, or other forms of refined and imaginative expression, than there is for concluding that artists, musicians, and poets have no interest in the attentive study of natural objects and phenomena. If science and documentary evidence are responsible for an age of prose, it is because the poets have been spinning cobwebs from their brains when they ought to have been learning something of the spirit and achievements of science. These are they who, having never entered upon scientific pursuits, are, to use Herbert Spencer's words, 'blind to most of the poetry by which they are surrounded.'"

Subjoined are some extracts:

Let me offer a few words on the effects of the relations of letters and science. We may obviously date a new time from 1859 when Darwin's "Origin of Species" appeared, and along with two or three other imposing works of that date launched into common currency a new vocabulary. We now apply in every sphere, high and low, trivial or momentous, talk about evolution, natural selection, environment, heredity, survival of the fittest, and all the rest. The most resolute and trenchant of Darwinians has warned us that new truths begin as rank heresies and end as superstitions; and if he were alive to see today all the effects of his victory on daily speech, perhaps he would not withdraw his words. That great controversy has died down, or at least takes new shape, leaving, after all is said, one of the master contributions to knowledge of nature and its laws and to man's view of life and the working of his destinies.

Scientific interest has now shifted into new areas of discovery, invention, and speculation. Still the spirit of the time remains the spirit of science, and fact and ordered knowledge. What has been the effect of knowledge upon form, or language, on literary art? It adds boundless gifts to human conveniences. Does it make an inspiring public for the master of either prose or verse? Darwin himself made no pretensions in authorship. He once said to Sir Charles Lyell that a naturalist's life would be a happy one if he had only to observe and never to write. Yet he is a writer of excellent form for simple and direct description, patient accumulation of persuasive arguments, and a noble and transparent candor in stating what makes against him, which, if not what is called style, is better for the reader than the finest style can be. One eminent literary critic of my acquaintance finds his little volume on earthworms a most fascinating book even as literature. Then, although the controversial exigencies of his day affected him with a relish for laying too lustily about him with his powerful flail, I know no more lucid, effective, and manful English than you will find in Huxley. What more delightful book of travel than the "Himalaya Journals" of the great naturalist Hooker, who carried on his botanical explorations some sixty years ago, and happily is still among us?

Buffon, as man of science, is now, I assume, little more than a shadow of a name, and probably even the most highly educated of us know little more about him than his famous pregnant saying that the style is the man—a saying, by the way, which really meant no more than that, while nature gave the material for narrative, it is man who gives the style. Yet the French to this day count him among the greatest of their writers for order, unity, precision, method, clearness in scientific exposition of animated nature, along with majestic gifts of natural eloquence. Then comes the greatest of all. Whatever the decision may be as to the value of Goethe's scientific contribution, this, at least, is certain, that his is the most wondrous, the unique case of a man who united high original scientific power of mind with transcendent gifts in flight, force, and beauty of poetic imagination.

As for science and the poets, only the other day an attractive little book published by Sir Norman Lockyer shows how Tennyson, the composer of verse unsurpassed for exquisite music in our English tongue, yet followed with unflagging interest the problems of evolution and all that hangs upon them. Whether astronomy or geology—terrible muses, as he well might call them—inspired the better elements of his beautiful work, we may doubt. An English critic has had the courage to say that there is an insoluble element of prose in Dante, and Tennyson has hardly shown that the scientific ideas of an age are soluble in musical words. Browning, his companion poet, nearly universal in his range, was too essentially dramatic, too independent of the scientific influences of his day, too careless of expression, to be a case much in point. Tennyson said of him, he had power of intellect enough for all of them, "but he has not the glory of words." Whether he had or not, science was not responsible.

I should like to name in passing the English poet who, in Lowell's words, has written less and pleased more than any other. Gray was an incessant and a serious student in learned tongues; and his annotations on the "System of Nature," by Linnæus, his contemporary, bear witness to his industry and minute observation as naturalist.

In prose fiction was one writer of commanding mind, saturated with the spirit of science. Who does not feel how George Eliot's creative and literary art was impaired, and at last worse than impaired, by her daily associations with science? Or would it be truer to say—I often thought it would—that the decline was due to her own ever-deepening sense of the pain of the world and the tragedy of sentient being?

Let us look at the invasion of another province by the spirit of the time. The eager curiosity of all these years about the facts of biology, chemistry, physics, and their laws has inevitably quickened the spread both of the same curiosity and the same respect, quickened by German example, for ascertained facts into the province of history. Is the pure scientific impulse—to tell the exact truth with all the necessary reservations—easy to combine with regard for artistic pleasure?

The English writer of our own immediate time, with the fullest knowledge and deepest understanding of the fact and spirit of history, would, I think, be pronounced by most critics with a right to judge, to be the late Lord Acton. Acton's was a leading case where knowledge and profundity was not matched by form. His page is overloaded, he is often over-subtle, he has the fault—or shall I call it the literary crime?—of allusiveness and indirect reference—he is apt to put to his reader a riddle or a poser, and then to leave

him in the lurch. Here is Acton's own account of the historian's direct debt to the methods of science: "If men of science owe anything to us," he says, "we may learn much from them that is essential. For they can show how to test proof, how to secure fullness and soundness in induction, how to restrain and employ with safety, hypothesis and analogy. It is they who hold the secret of the mysterious property of the mind by which error ministers to truth, and truth irrecoverably prevails."

Where the themes and issues are those of scientific truth, that prose should be unemotional is natural. Everybody knows Darwin's own account, how, as the laborious years passed, he so lost his taste for poetry that he could not endure to read a word of it; Shakespeare became so dull it nauseated him, and music set him thinking too energetically on what he had been working at, instead of giving him pleasure. If all this loss was the price of years of fruitful concentration in the matter, who can wonder if the scientific and documentary age is an age of prose?

The Air-brake as Related to Progress in Locomotion—II*

The History of a Great Invention

By Walter V. Turner, Chief Engineer, Westinghouse Air Brake Co., Philadelphia, Pa.

Continued from Supplement No. 1840, page 214

RECENT DEVELOPMENTS IN TRAIN BRAKE APPARATUS.

The typical brake equipments which have been mentioned, namely: Straight-air, plain-automatic, quick-action-automatic and the high-speed brake, mark epochs during which the respective equipments were each able to successfully meet the traffic requirements existing for the greater part of the periods during which they were supreme, but as the demands of service became steadily more severe, each in turn gave way to its successor, the improved equipment in each case being in its turn satisfactory for such a time as the conditions which brought it into being were not greatly changed.

This growth, it will be noted, was along lines of improving the degree of efficiency of the fundamental functions of the original plain triple valve, either by increasing the air pressure carried for braking purposes, or by the aid of additions to the valve structure itself, or by the attachment of additional devices to existing apparatus, or by combination of two or more of the expedients just mentioned.

With the high-speed brake, the practical limit to improvement along such lines was believed to have been reached. For some time little or no improvement was thought possible, and this was indeed a fact, so far as further progress along lines previously followed was concerned, for two reasons. (1) About all was then being obtained from the old type of brake that could be gotten from it with the mechanism and arrangement of apparatus then existing. (2) New conditions requiring more specialized apparatus and refinement of the service and emergency features of the brake, as well as of the safety and protective features, began to develop with a rapidity which made it evident that a turning point had been reached.

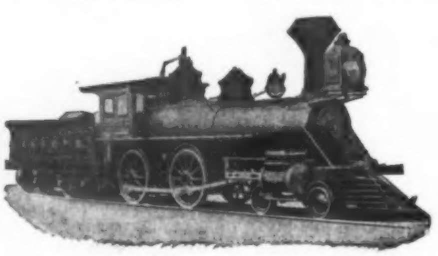


Fig. 11.—AMERICAN TYPE OF LOCOMOTIVE, 1879

As a matter of fact, it was rapidly becoming apparent, not that the air-brake had advanced relatively to the requirements, but that it had not kept pace with the developments of locomotion. In other words, that even the most efficient brake of to-day is, at its best, not able to control and stop a train in the same distance as when the weight and length of the train was less than one-fourth of that to-day. That we have done as well as we have will be appreciated when it is considered that the length of the trains and the volume of air employed have rendered this vastly more difficult, as to service control, and the weight (which involves many factors) to the extent that it would require at least twice the distance in which to stop if the old brake had to be used with present-day conditions.

In addition to the increased weight and speed of trains, there were, of course, increased number of parallel tracks and frequency of trains. These always bring with them braking problems quite as difficult of solution, and as necessary to be solved, as those which preceded them, particularly as the tendency is to neutralize or lower the value of many of the factors involved in producing and realizing retarding forces.

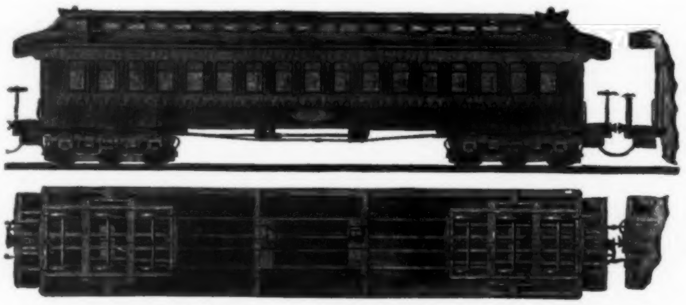


Fig. 13.—P. R. R. PASSENGER CAR, 1872

It is difficult for one who has not given the subject careful thought to realize the great changes in railroad equipment and operative requirements which have taken place since the introduction of the air-brake, but it is only necessary to review briefly these past and present conditions in order to appreciate the necessity for a similar development and improvement of the apparatus used for controlling trains under these new conditions.

The following comparative tabulations comparing the conditions existing from 15 to 20 years ago and those of to-day with regard to extent of territory covered, capital involved, traffic handled, and so on, will perhaps illustrate the conditions that now have to be faced better than the mere statements which have just been made.

Railroad Development From 1889 to 1909.

	1889	1909	Increase, Per Cent.
Miles of line	153,385	234,182	52.7
Miles of track	195,958	340,000	73.5
Net capital, etc	$7,366,745,000	$13,508,711,000	83.3
Passengers carried	472,171,000	880,764,000	86.5
Tons freight carried	539,639,000	1,486,000,000	175.3
Locomotives, number	29,036	57,220	197.0
Freight cars, number	829,885	2,113,150	154.6
Employees, number	704,743	1,524,000	116.2
Employees, compensation	$389,785,564	$1,003,270,000	157.4
Electric railways	....	50,000	...

Locomotives.—The weight on drivers has increased since the air-brake was invented, from 25,000 pounds to 400,000 pounds.

The drawbar pull of locomotive has increased, since the air-brake was invented, from 10,000 pounds to 100,000 pounds.

The total weight of locomotives at the present time is as high as 700,000 pounds.

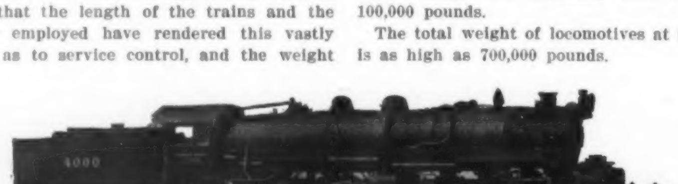


Fig. 12.—MALLET ARTICULATED LOCOMOTIVE—ATCHISON, TOPEKA & SANTA FE RAILWAY, 1909

Working steam-pressure has increased, since the air-brake was invented, from 125 pounds to 225 pounds.

Passenger Cars.—Weights have increased from 20,000 pounds to 150,000 pounds.

Freight Cars.—Light weight of car has increased from 12,000 pounds to 50,000 pounds.

Capacity has increased in the last twenty years from 40,000 pounds to 150,000 pounds.

Passenger Trains.—Schedule speeds have increased from 30 miles per hour to 65 miles per hour.

The energy contained in a five-car train of cars having an average light weight of 30,000 pounds per car, running at a speed of 35 miles per hour, is 6,200,000 foot-pounds; of cars having average weight of 127,000 pounds, running at 65 miles per hour it is 90,000,000 foot-pounds, or nearly fifteen times as much.

Freight Trains.—Train length has increased from 15 to 130 cars; total weight has increased from 300 to 4,500 tons and in certain places in the country as high as 6,000 tons.

To take an actual example illustrating what is involved in the handling of a modern high-speed passenger train, the following figures are taken from the official report of the Emergency Brake Tests carried on about a year ago by the Lake Shore & Michigan Southern Railway near Toledo:

Lake Shore Emergency Brake Test.

Types of vehicles used.	Weights. Pounds.	Tons.
Locomotive—Pacific type	388,000	194.0
Buffet car	149,000	74.5
Dining car	140,000	70.0
Sleeping car average	125,000	62.5

Energy in Test Trains.

Make up of train	2 Loco.—10 Cars	1 Loco.—6 Cars
Train weight—pounds	2,068,000	1,180,000
Train weight—tons	1,034	590
Energy at 40 M. P. H., foot-pounds	116,816,000	66,595,200
Energy at 40 M. P. H., foot-tons	58,408	33,298
Energy at 60 M. P. H., foot-pounds	262,836,000	149,839,200
Energy at 60 M. P. H., foot-tons	131,418	74,920
Energy at 80 M. P. H., foot-pounds	467,264,000	266,380,800
Energy at 80 M. P. H., foot-tons	233,632	133,190

Kinetic Energy* in Train of 2 Locomotives, 10 Cars of 75 Tons Weight Each—Total Train Weight, 2,276,000 pounds, or 1,138 Tons.

Speed	40 M. P. H.	60 M. P. H.	80 M. P. H.
Foot-pounds	127,811,200	287,575,200	511,244,800
Foot-tons	63,906	143,787	255,622

Figs. 11 and 12 present a tangible evidence illustrative of both extremes of the locomotive development indicated in the tabulations just given. The view of the American type of locomotive (Fig. 11), representing standard practice of 1879 can, no doubt, be recalled by many, and is in marked contrast with the enormous Mallet Compound Locomotives (Fig. 12) now being introduced for heavy grade service in various parts of the country.

Similarly the progress in passenger car construction is graphically illustrated by comparing the typical passenger car of 1872 (Fig. 13), with the modern all-

*Presented at the meeting of the Mechanical and Engineering Section.

*Kinetic energy in train of 2 locomotives, 10 cars of 75 tons weight each—at speed of 80 M. P. H. is sufficient to raise 1 ton to a height of over 48 miles.

steel Pullman cars (Fig. 14), which are being built at the present day.

All the figures which have been given report the maximum conditions of past and present-day practice. As the application of the air-brake has made this enormous increase in weight of vehicles, speeds and length of trains possible, it is fair to assume that the stopping power of the brake should logically be increased in the same proportion so that the stop should be no longer now than formerly.

A concrete example will show forcibly just what this increase in weight and speed means to the operating department if it is to accomplish such an admittedly desirable and necessary result. Under the former conditions the factor of safety in train handling was none too large and it is therefore imperative that we should be able to control modern trains under present existing conditions at least as safely and efficiently as formerly. To do this for five 150,000-pound coaches running at 65 miles per hour, it is necessary to provide means for controlling over 105,000,000 foot-pounds of energy as compared with about 6,000,000 foot-pounds which was all that the brake of the early 70's was called upon to control with a train of five 30,000-pound cars running at 35 miles per hour. When the locomotive used with each train is considered, the total energy in the modern train becomes 162,000,000 foot-pounds, as compared with 9,800,000 foot-pounds, for the train of 1870. It is not surprising, therefore, that the air-brake art demands thoughtful consideration from trained and experienced minds if the railroad traffic of to-day is to be handled with a safety and efficiency even equal to that of the days when the total energy to be reckoned with was one-sixteenth as great. Here again is found another close resemblance between the conditions of acceleration and deceleration, for while it is not especially difficult to increase the speed of a train from 30 miles per hour to 40 miles per hour, it requires the expenditure of a vastly greater amount of energy to increase its speed from 60 miles per hour to 70 miles per hour. In like manner, for any given increase in speed the additional amount of work required from the brake increases in geometrical, not arithmetical, ratio. If, therefore, the improvements for the heavier trains and higher speeds of to-day permit of stopping in about the same distance as could be done with the brake of forty years ago, and the trains of that period, we should congratulate ourselves for having held our own.

The mere power necessary to accomplish this is indicated by the fact that the total maximum force exerted by the push rod of the 6-inch brake cylinder of the early equipment was 1,700 pounds, while with the 18-inch brake cylinder used on the heaviest coaches, a maximum pressure on the push rod of 26,670 pounds is obtainable.

From the foregoing it will be apparent that many features must now be considered which did not exist when the brake was first invented, particularly on the physical side of the problem. For example, the amount of work required per square inch of brake-shoe surface is vastly greater. This is a condition seldom noticed and yet of great significance, as the following comparison will show:

In the report of one of the earliest brake trials in the history of continuous brakes, made on the Midland Railway, near Newark, England, in 1875, and since known as the Newark trials (see London *Engineering*, June and July, 1875), the best brake performance recorded was by a train of fifteen 21,000-pound (average) four-wheel carriages, fitted with a primitive form of the Westinghouse automatic-brake, one cast-iron brake-shoe being used on each wheel. The best stop was made from a speed of 52 miles per hour, the highest that could be obtained, in 18 seconds. This corresponds to the performance of 15.5 foot-tons (1 ton = 2,000 pounds) of work per brake-shoe per second. In the classic Westinghouse-Galton tests, which followed about three years later, the four-wheel experimental van used weighed 18,200 pounds, and was fitted with two brake-shoes per wheel, and from 52 miles per hour speed a stop was made by the experimental van alone in 11½ seconds. Here the work done was only about 9 foot-tons per brake-shoe per second.

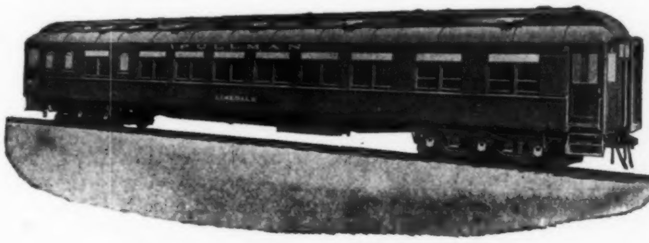


Fig. 14.—ALL-STEEL SLEEPING CAR, 1909

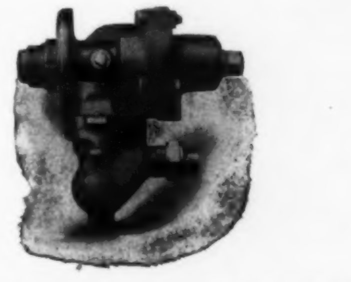


Fig. 16.—TYPE "K" FREIGHT TRIPLE VALVE

In 1875 the standard passenger coach used on the Pennsylvania Railroad weighed 39,300 pounds and had four-wheel trucks. To stop such a car from 52 miles per hour in 18 seconds required only 12.33 foot-tons of work per brake-shoe per second, or less than that required of the brake on the Midland train, although the Pennsylvania car weighed 18,300 pounds more. This is, of course, due to the fact that eight brake-shoes were available to do the work as compared with four on the Midland train. Contrast with the above a modern Pullman car weighing 160,000 pounds and having six-wheel trucks. Assuming that from a speed of 52 miles per hour that stop could be made in 18 seconds, the work done would be 33.5 foot-tons per brake-shoe per second, or over twice that of the Midland train, notwithstanding that there are twelve brake-shoes to do the work instead of four. But modern express train speed may be expected to run frequently as high as 75 miles per hour, and to make a stop from this speed in, say, 35 seconds (which would be about the best that could be expected of the modern brake equipment) would require 35.8 foot-tons per brake-shoe per second, or not much more than when a stop of 52 miles per hour is made in 18 seconds. But to have the same absolute safety under modern conditions as existed in 1875 would require the stop to be made in at least the same distance and time, and to stop a 160,000-pound car from a speed of 75 miles per hour in 18 seconds would require 69.6 foot-tons of work per brake-shoe per second or about 4½ times that in the case of the Midland train. (What this would be with four-wheeled trucks will be appreciated.) Even if two brake-shoes per wheel could be used instead of one there would still be over twice as much work to be performed by each brake-shoe per second if the trains of to-day at the speeds now attained in high speed service are to be relatively as safe as the trains of thirty years ago. Furthermore, the use of two brake-shoes per wheel is rapidly becoming a necessity, not only on account of the great amount of work to be performed by each brake-shoe, but also because the brake-shoe pressure required by modern conditions of high speeds and heavy cars are becoming so great that in emergency applications a heavier pressure is brought to bear on the axle and journals by the brake-shoe acting on one side of the wheel only than is imposed by the weight of the car resting on that wheel.

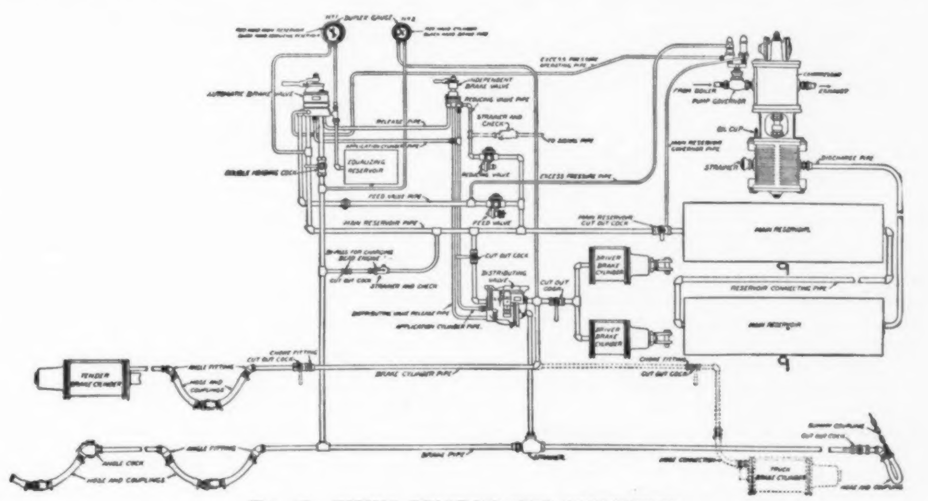


Fig. 17.—PIPING DIAGRAM "ET" EQUIPMENT

The tremendous significance of this increase is but faintly appreciated by those who have not had occasion to investigate this aspect of the question. The cast-iron brake-shoe is to-day practically as it was thirty years ago. This brake-shoe must now do four times the amount of work by frictional resistance to the rotation of the wheel, as formerly. It may be suggested, "Why not quadruple the pressure per brake-shoe?" But it also must be remembered that when the brake-shoe pressure is multiplied by four, the actual retarding force is by no means quadrupled, for three vital adverse factors are being overlooked, viz., the effect of increased pressure, speed, and temperature on the coefficient of friction between the wheel and the shoe. Exactly how great an effect these may have depends, of course, on the conditions of the individual test considered, but that it is considerable is proven by the fact that a stop from a speed of 75 miles per hour in 35 to 40 seconds, instead of 18 seconds, is considered good, although we are to-day using about four and a half times as much pressure per brake-shoe as at the Newark trials.

It should be stated that in the above no account is taken of the rotative energy of the wheels. If this is considered, it is evident that the figure for the modern conditions will be still more in excess of those of the past, on account of the wheels being heavier and there being a greater number per vehicle.

Again, the difference in air pressure required to apply and release the brakes is by no means as easily obtained to-day as when trains were short. The air supply required for short trains with small brake cylinders was obtained with compressors of much less

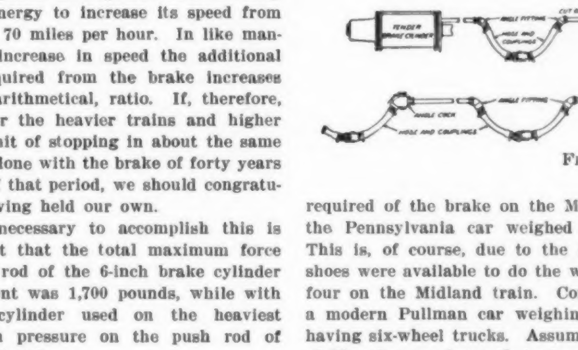


Fig. 15.—IMPROVED PASSENGER BRAKE EQUIPMENT, TYPE "LN"

capacity than is now necessary to employ; witness, the 6-inch air compressor of the early days of the brake, with its capacity of not over 15 cubic feet per minute, as compared with the cross compound compressors now used, which have approximately 125 cubic feet capacity. The reason for this is apparent, for it required, not so very long ago, about 25 to 30 cubic feet for a full application; now 300 cubic feet is required.

In general, therefore, it may be stated that the brake which would satisfactorily meet the requirements of past conditions, falls short of the maximum efficiency which it should be possible to attain, in proportion to the increase of the requirements of present-day service over those of the past. The force of this is apparent when the same comparison is made between the locomotives and cars of the two periods. This review of the conditions and what is involved, which is by no means exhaustive, will serve to give an idea of the magnitude of the problem. How the various stages of this problem have been solved, as they presented themselves, will be shown best by a consideration of the features and functions of the improved brake apparatus that was developed to meet the conditions just explained.

CHARACTERISTICS OF IMPROVED BRAKE EQUIPMENTS.

While the fundamental service and emergency features of the quick-action brake could not be departed from on account of the necessity for maintaining interchangeability of apparatus, and operative function, it was clear that in designing a brake to meet these new conditions, not only must the fundamental features of the old brake be improved to their highest possible efficiency, but new features must be added, some of which were inherently impossible if the design were carried on along the lines previously laid down.

With this as a point of departure, the development of the newer forms of locomotive, passenger and freight brakes was commenced and it may be fairly said that with the incorporation of the new features which will be explained in what follows, the air-brake entered upon a new era of its history as distinct from that which preceded, covering the progress of the art from the development of the plain automatic brake to the high-speed brake, as that era was distinct from those of the straight air-brake and of the hand-brake which marked the earlier history of the art.

Briefly stated, the recognition of the new principles required by the changed conditions referred to, led, in the case of the passenger brake, to the incorporation of the following features in addition to those characteristic of the previous form of equipment: (See Fig. 15.)

1. Quick rise of brake-cylinder pressure so that the braking power may reach its maximum in the shortest possible time and thus begin to be effective in reducing the speed when at its highest value—and when the increase in distance run before coming to a stop is greatest for every second's delay.

2. Uniform braking power on all cars, irrespective of size of equipment and variation in piston travel, thus contributing largely to the convenience and comfort of passengers, as well as making the brake more reliable and therefore easier to manipulate.

3. Maintenance of both service and emergency-brake cylinder pressures up to the capacity of the ample storage reservoirs of the cars. This is of the greatest advantage in overcoming the ever present and often serious depletion of brake-cylinder pressure by packing-leather leakage.

4. Predetermined and fixed limiting of maximum service braking power, without a safety valve or other blow-off device. This maintains the proper margin between the power of service and emergency applications and tends to reduce wheel sliding without wasting air and with a minimum of apparatus thus resulting in economy both of operation and maintenance.

5. Quick service feature to compensate for increased length of train and bring about more prompt, uniform and certain application of brakes.

6. Quick recharge of the auxiliary reservoirs to offset longer trains and larger cylinders and reservoirs and insure a prompt application of the brakes when desired and prevent the depletion of the auxiliary reservoir pressure.

7. Graduated release feature to add to the flexibility of the brake by making it possible to graduate the brakes off as well as on and so to handle the train more smoothly, with a greater saving of time, and a reduction in the amount of wheel sliding.

8. Much higher brake-cylinder pressure obtained in emergency for the same brake-pipe pressure carried, which pressure is maintained and retained during the complete stop, thus materially shortening the stops and adding greatly to the safety of the trains.

9. Automatic emergency application on depletion of brake-pipe pressure. This is a safety and protective feature of great value, in that it insures sufficient braking power being automatically obtained to bring the train to a stop in case the system is depleted below a predetermined pressure either by careless manipulation or accidentally.

10. Full emergency braking power at any time, thus placing the maximum stopping power the brake has to offer at all times ready for use by the engineer whenever an emergency arises, irrespective of what may have preceded.

11. Separation of service and emergency features so that the necessary flexibility for service applications can be obtained without impairing in the slightest the emergency features of the equipment and conversely, so that undesired quick action is practically impossible.

12. High maximum braking power secured with low total leverage, with correspondingly greater overall efficiency of the brake.

13. Better mechanical design resulting in more uniform wear of parts and ease of access for removal or repairs.

In the case of the freight brake, the change in the conditions which require a change in apparatus were in the direction of greatly increased length of trains, and difference between the light and loaded weights of the cars. The features of the new freight brake were therefore developed with particular reference to those considerations as follows: (See Fig. 16.)

1. Ability to apply and release the brakes without fear of shocks, under conditions where they are certain with the old brake, gives an added value to all rolling stock.

2. As only a comparatively light reduction is required with the quick service valves to apply all the brakes and with uniform cylinder pressure, there is not sufficient braking power developed in any one part of the train to cause the slack to run in or out severely. On the other hand, with the old brake, a heavy reduction is required to apply the brake at the rear of a long train, the effect of which is to bunch the slack severely with consequent running out again as the brakes take hold at the rear and the draft springs recoil. As shock is the complement of time and the place where the retarding force is developed, it will be seen that shocks, due to brake applications, will be greatly reduced with the new valve, for while the time required to dissipate the energy of the moving train will be the same, the distribution of the braking power will be different, as it will be divided among all the vehicles in the train instead of first at one end and then at the other.

3. Because more applications and release can be made in the same time with the new brake than with the old—much better control and safer operation of the long trains are obtained.

4. On account of the uniform release feature, and because a maximum or full service application of the brake is seldom required with the new brake, the release is more prompt and certain at the rear (which, as has been shown, is the vital place of a long train), and the number of "stuck brakes," flat wheels, and shocks are greatly reduced, particularly as no damage can be caused by the engineer opening the throttle before the brakes at the rear have released.

5. The uniform recharge feature assists in this, inasmuch as the number of "stuck brakes" (resulting from a re-application due to over-charging after a release) is reduced and more equal response of all the brakes secured for subsequent application.

6. The quick service feature makes possible much shorter stops, which is important at all times, but particularly where block signals are in use. This makes unnecessary quick action applications of the brake except in cases of actual danger.

7. The uniform release feature in grade work to a large degree acts as an automatic retaining valve, which is one of the factors in the increased control.

8. The uniformity of application and release tends to reduce the serious effects of the wide difference of braking power with loaded and empty cars in the same train.

9. That vital factor in train control, the personal equation, is made more uniform; as less skill and judgment is required to get good results, while lack of these cannot result in so much harm.

10. As the air required to obtain the same control is only one-third of that required by the old brake, there is much less danger of the supply being inadequate, and with brakes in a reasonably operative condition, there is more likelihood of the engineer stalling or stopping than of "losing his air."

11. Much shifting of lading and breaking-in-two now caused, independent of the brake, by stopping and starting, will be eliminated, as slow downs instead of stops can be made.

12. More tonnage can be handled, and at higher and more uniform speeds, with safety, than has heretofore been possible.

13. Accidents, due to broken wheels, will be fewer, as with the new valve each brake does nearer its share of the work; thus, the excessive heating, due to hand brakes being used, or a few brakes doing the work, no longer takes place.

14. (*a*) The old valves are greatly helped by the new ones when mixed in a train. (*b*) The new features are simply additions to the old valves, the fundamental operative functions and principles remaining the same as in previous forms.

15. With the empty and load brake, greatly increased tonnage can be handled, with equal or even more safety, and for mixed empties and loads in the same train the elimination of damaging stresses due to inequality of braking power on empty and loaded cars. The characteristics of this equipment and its peculiar advantages merit a more extended description which will follow a little further on.

In the case of the locomotive brake, the new features characteristic of the improved equipment were naturally in part due to the necessity for bringing the locomotive equipment up to an equal efficiency with the improved passenger and freight brake apparatus as just outlined.

In addition, however, certain desirable operative features had long been recognized, but remained impracticable until the establishment of a new basis for design afforded an opportunity for including in a compact and mechanically satisfactory combination of parts, all that previous experience had shown to be desirable in an efficient locomotive brake (see Fig. 17). Briefly stated these are as follows:

1. Either entirely independent or simultaneous operation of the train and locomotive brakes as may be desired, thus permitting of much greater degree of convenience and flexibility in handling long trains, especially on grades, in switching, etc.

2. Maintenance of brake-cylinder pressure whether partial or full application, up to the capacity of the compressor, thus insuring that the desired amount of braking power on the engine will be obtained and maintained irrespective of the leakage which is so difficult to prevent in the case of locomotive brake cylinders especially.

3. Uniform brake-cylinder pressure in all brake cylinders on the locomotive, irrespective of piston travel, number of cylinders or leakage, thus doing away with the necessity for different size or type of operating mechanism for different sizes of cylinders or types of locomotives as well as insuring against variations in braking power due to differences in piston travel, which must always be reckoned with on account of the brake-shoe wear or neglect in adjustment.

4. Predetermined and desirable increase in emergency brake-cylinder pressure over the maximum obtainable in service, thus securing for the locomotive brake equipment an advantage long recognized as fundamental for all car-brake equipments.

5. Automatic protection against loss of air required for braking due to brake-valve handle being left in lap position by mistake.

6. Graduated release feature for the locomotive brakes which will then work in harmony with the new graduated release type of passenger car brake.

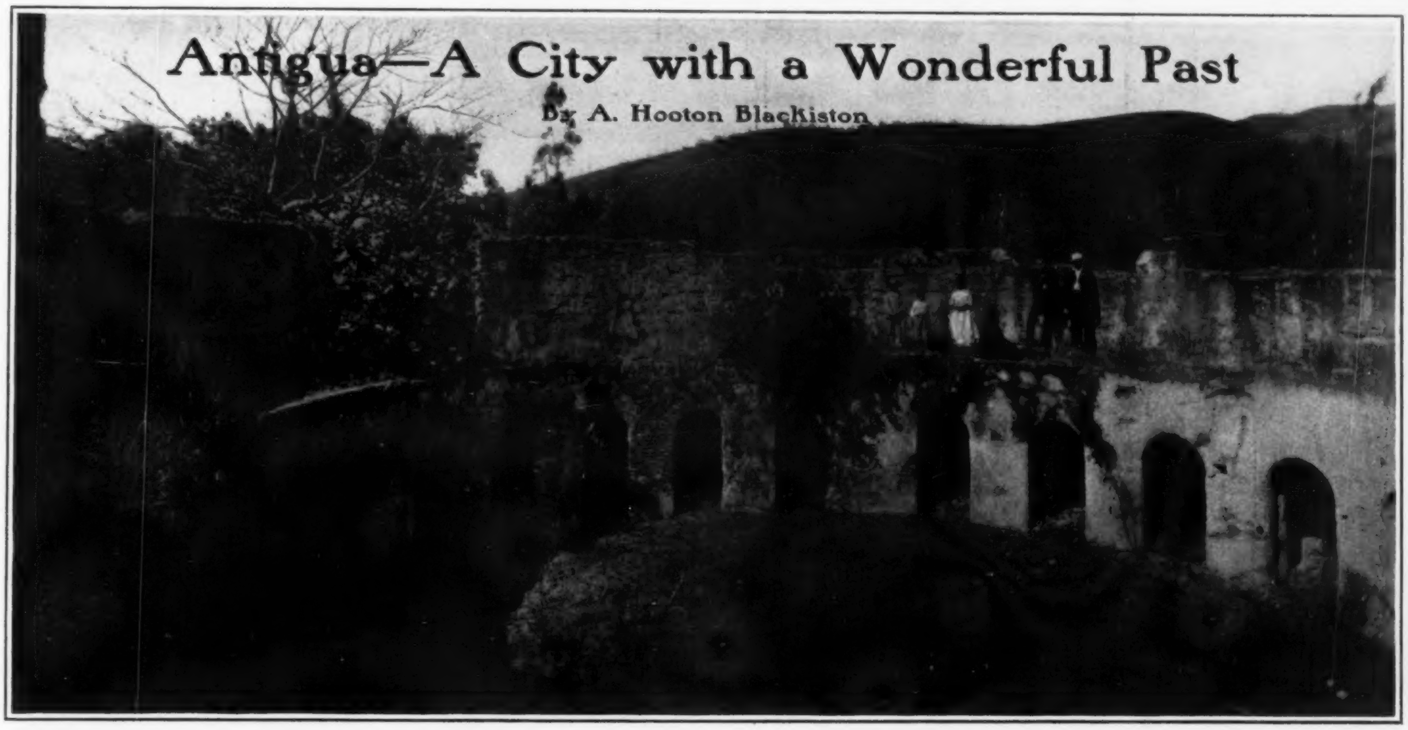
That the above features are all in the direction of increased convenience, economy and safety in the handling of both passenger and freight traffic, is self-evident, but when it is further considered that these advantageous improvements have been incorporated in a combination of apparatus less complicated and with fewer number of parts than required by the old equipment at its best and that the mechanical design and arrangement of parts has been greatly improved with respect to minimizing the wear due to ordinary service and in increased ease of maintenance and repairs, it will be seen that the character and degree of the improvements which have been made are in accord with, and not antagonistic to, the demands of modern railroad service for apparatus of the highest efficiency coupled with a maximum of economy and a minimum of complexity.

(To be concluded.)

A new instrument for measuring nocturnal terrestrial radiation, invented by the late Knut Angström, is described by his son, A. K. Angström, Jr., in *Annalen der Physik*, under the name of "condensation-actinometer." Excepting an external cylinder of metal, the instrument is made entirely of glass. It consists of a reservoir, exhausted of air, and containing ether, into which projects a glass chamber, open above to the air, and coated with lampblack. The blackened surface radiates heat more rapidly than the rest of the apparatus, and tends to lower the temperature within the reservoir; this cooling is, however, compensated by the condensation of ether, which distills over into a graduated glass tube. The total amount of radiation from the black surface during a given interval is proportional to the amount of ether condensed. Its value in thermal units may be obtained by the use of a constant, determined by comparing the instrument with other actinometer.

Antigua—A City with a Wonderful Past

By A. Hooton Blackiston



RUINS OF A CONVENT IN ANTIGUA: THE CELLS OF THE NUNS

For many years after the signal conquest of the Aztecs by Cortez, adventurous gentlemen at arms, fired by his success and by the still more potent lure of tales of fabulous riches, formed numerous expeditions to penetrate the fastnesses of the New World. Pizarro lead his unscrupulous band to plunder the golden land of the Incas, Olid conquered Honduras, Ponce de Leon searched for the Spring of Eternal Youth, Coronada journeyed toward the fabled Seven Cities of Cibola and De Soto endeavored to penetrate the southern wilds to the great Pacific, while Cortez himself explored the country from Mexico to what is now Puerto Cortez Honduras, but which he named Puerto Caballos from the number of horses lost in landing there.

It was, however, left for Don Pedro Alvarado, the most unscrupulous and dashing of his lieutenants, to conquer the powerful nations of Quiches, Cakchiquels and Mams, who dwelt in what is now Guatemala or Quahtemala, as the Indians then called it, meaning "Land covered with trees."

About the year 1524 Alvarado led an expedition of one hundred and twenty horsemen, one hundred and thirty cross bowmen and one hundred and seventy men-at-arms, together with an auxiliary army of nineteen to twenty thousand natives against the allied Quiche forces under the command of Kicab Tenab, the Quiche chieftain. The often enacted tragedy took place; through intrigue, false promises, ancient tribal animosities and superior armament, the native forces were already doomed when the rival armies clashed upon the plains of Quetzaltenango ("place of the quetzal," the native bird of Guatemala at the present time).

Here under the warm tropical sun the battle waged throughout the day, and many were the deeds of valor and desperation performed on both sides. Confronted by wonderful weapons in the hands of strange beings mounted on their terrible horses, the Indians fought long and well, while ever in their front moved the glittering plumes and dripping spear of Tecum, the valiant son of Kicab Tenab, with his nagual or familiar spirit in the form of a quetzal hovering—according to legend—constantly over his head.

Finally the two chieftains of the opposing forces met, and all of Alvarado's skill availed him naught against the courage and the nagual of the Indian, for as long as the quetzal lived Tecum could not be harmed. At last a Spaniard by the name of Arguete killed the nagual, and tradition has it that Tecum then fell dead at Alvarado's feet and the native forces broke and fled. The family of Arguete in Spain bears to this day the quetzal upon its coat of arms in memory of that distant encounter upon the plains of Quetzaltenango by which the Spaniard won a new empire and countless thousands lost their birthright, while the Cakchiquels and the Mams were in turn reduced through treachery and the sword.

The fate of the Indians was then only too plain—harsh servitude for life under heartless masters. They were branded with red-hot irons and sold like cattle, one-fifth of the selling price going to the royal treasury of Spain. Alvarado even casually reports burning some Caciques with their towns as he thought "in all probability it might have a wholesome effect upon the ones left living," the effect upon the others being tactfully ignored. Stone was quarried and shaped, bricks made and wood hewn by the Indians, while thousands more of the erstwhile lords of the soil toiled upon the churches and palaces, the houses and fortifications of the capital of the newly acquired province of Imperial Spain. This with fatal choice Alvarado had located upon the lower slopes of the great volcano of Hunapu in the beautiful valley of the Almoconga high upon the central plateau. Little was feared from this grim guardian of the town which reared its head over twelve thousand feet into the clear blue skies, as it had long been quiescent and a great lake of water had formed in its crater, while two other still higher peaks nearby frowned down upon the misdeeds of the conquerors.

So the new capital grew in wealth and importance sumbering in fancied security in the shadow of the great volcanoes, while Don Pedro Alvarado, having worked long and ardently for the devil, in the name of the Lord was made Adelantado, Governor and Captain-General of all Central America in the year 1530, and ruled in state from the newly founded city. After various voyages to Peru, Spain and in search of the Spice Islands, he was finally killed in Mexico by a falling horse, and doubtless laid to rest with all the pomp and ceremony due such a great lord of toiling thousands, who slaved because nature had endowed them with a belief in the word of their fellow man, a fair country and inferior weapons.

Yet through it all the Indians well knew that Sicapua, the god who made the mountains, and his brother Cabrakan, who made them tremble, were merely biding their time to crush the invader and avenge the wrongs of their children. And so it came to pass that on a certain terrible night, September 11th, 1541, but one day after Alvarado's widow, Beatriz de la Cueva, had been named to serve in his stead, the voice of the earthquake was heard throughout the land, and mid the rending of the falling walls and the shrieks of the doomed, sounded the wild rushing of the waters which poured in an avalanche through a great rent in Hunapu's cone upon the fated town, sweeping all before it and leaving but a few solitary ruins where once had stood the glittering capital. Many hundreds were killed, among them the wife of Don Pedro Alvarado.

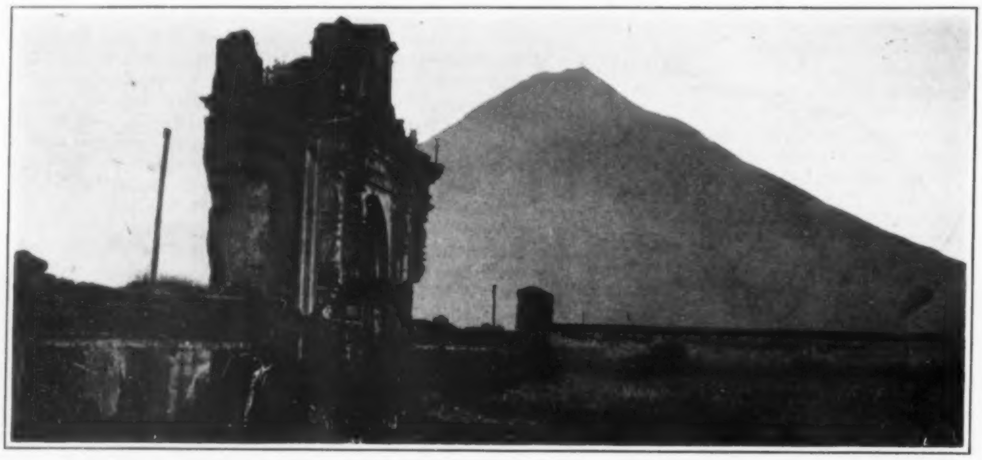
All that is left to-day are a few sad remains consisting largely of the foundations of a spacious palace and a portion of the crumbling walls of what must have been the old cathedral. The natives called the houses clustered about these monuments of the past Cuidad Veihe, or the Old Town, in contradistinction to Antigua or the second capital.

Many traditions were connected by the Spaniards with this great catastrophe, for men were then as fond of moralizing as they are now, and were less satisfied with apparent reasons when supernatural ones could be applied. The widow of Don Pedro Alvarado, so runs the legend, had given herself wholly up to mourning her noble lord whose amiable traits doubtless grew in direct proportion as the years elapsed. So overcome was she by his loss that she never stirred from the house, but spent the long days shut out from the sunshine and the flowers in the darkest room of the palace, the walls of which were even painted as black as the clothes she and her retinue wore. No light, no color, no bright blossoms were allowed to intrude upon her sorrow; so consuming was it that she even lost that comfort and hope to which all are taught to cling when everything else has failed. And so the earthquake came and the great lake burst its confinement to overwhelm the devoted town that by its waters might her sin be washed away, and mankind warned for all time against permitting his personal sorrows to supplant the teachings of the church.

Hence it transpired that the Spaniards moved their capital four miles distant, away alike from the unhallowed spot and from the mountain which had been the agent of their doom that once again might this portion of the New World bear the yoke of Spain and yield to the old its golden flood. Complete as had been the revenge of the native gods, it was but short lived, for the new city was built on a far grander scale than the first one by the unceasing toil of the Indians, and once more the white walls gittered in the sunlight beneath the blue skies that overhung the great volcanoes. The churches—high vaulted and thick walled—sprang up by the score, and the inquisition in its darkest form appeared to wring in unspeakable tortures the lives from unknown thousands. The natives, though supposed to be immune, were frequently conveniently put out of the way by this means that alone has branded the early Spaniard as decidedly the spiritual inferior as he was undoubtedly the moral and in many material ways of the "savages" whom he conquered. Alas that it should remain for "civilized" man to slay by torture that others might be forced to sink to his level of religious degradation, and that the frail hand of Isabella of Spain should have left to the world such a bloody legacy! The conquerors were not only not contented to grind the vanquished under foot, to force them to build their towns and work in the mines and fields, to naively burn them alive in their dwellings and subject them to the tender mercies of the Inquisition, but they further destroyed the wonderful Mayan manuscripts which contained priceless records of the past, in much the same manner as the bigot priest Zumuragua in Mexico piled the Aztecan codices "mountain high" and applied the torch that thus might "the works of the devil" be removed by one of his choicest disciples.

Yet in spite of the darkness of its crimes of which only an incomplete record has come down to us, the low-roofed town in its surrounding of tropical verdure waxed rich and powerful; its narrow streets were paved with stone, and the sidewalks, hardly broad enough for two, abutted upon the walls of white, buff and blue from which projected the iron barred windows to safely guard the dark-eyed senoritas who gazed upon the passing cavaliers. Its plazas and avenidas glittered with life when the music sounded on the moonlit nights, and the breeze that stirred the palms and ceibas was heavy with the fragrance of orange blossoms. Eight great monasteries, five convents, and three *beaterias* housed those of the re-

THE RUINS OF "SANTO DOMINGO"



THE CHURCH OF "RECOLECCION." THE PEAK OF AGUA, 12,000 FEET IN HEIGHT, IN THE BACKGROUND

RUINS OF THE CHURCH OF "CONCEPCION"

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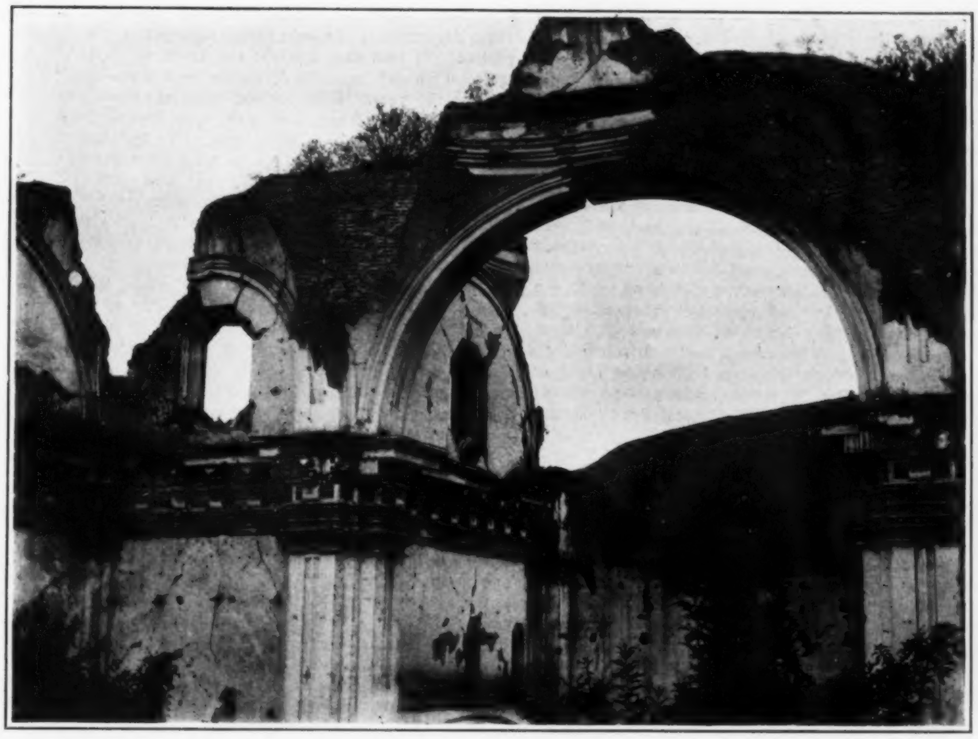


SIDE VIEW OF THE RUINS OF THE CHURCH OF "RECOLECCION"

REMAINS OF THE "SCHOOL OF CHRIST"

RUINS OF THE CHURCH OF "RECOLECCION"

AMERICAN C WITH A WONDERFUL PAST

ligious orders, or whose affiliations were close to Mother Church. Two extensive hospita's nursed and comforted the ill in body, while three massive jails held securely in their cells and dungeons those whom it was deemed expedient to keep in captivity. Yet above all it was Antigua's crowning glory that she boasted over a half a hundred churches within her borders whereby much good seed was scattered broadcast upon the virgin soil.

Round about the city like the setting of a diamond, clustered seventy picturesque villages, each under the charge of a priest and to each of which was assigned the manufacture of some special article. In one was found the excellently carved woodwork of which we see specimens to-day, and for which the native displays a singular aptitude; in another pottery, glazed, polished, rugose and polycrome, while in others iron was fashioned, bricks baked or basketry or clothing manufactured. For in proud Antigua none of the trades were plied, as it was essentially a governmental, religious and social center.

Ere the first lights of early dawn had gilded Fuego's brow, long lines of merchants could be seen wending their way from the surrounding towns to the great central plaza, or open air market, there to display their wares to the wakening city, and long before sunset the same lines, ant-like, crept toward their homes again.

Shaded driveways led through the surrounding country to the fincas and the medicinal baths, as even at the present time the valley of the Almocongo is noted for its thermal waters and the rich volcanic ash of its soil.

Tribute from the Indians and gold and silver from the mines for many distant leagues poured into its coffers, for the suzerainty of Antigua reached from the forests of Yucatan to the gold strewn shores of distant Darian, and from the Pacific to the Atlantic. Broad paved roads were built from the coast to the interior, and many an hidalgo with an eye to the future as well as to the present brought paintings from Spain to grace the stately churches and convents of the proud mistress of all Central America. Deep toned bells of bronze, cast in the foundries of Toledo or Seville, were shipped across the seas to the shores of the New World and then carried up the rivers on barges to later be transported through the forests and over the mountains to their final resting place in the graceful belfries of San Francisco, San José and the many other churches, that there they might call alike the chosen and the heathen to prayer and save the souls of erring man. Yet one bell there was that never reached its destination, for after safely passing the dangers of the sea, it was lost in the murky waters of the Rio Chamelecon. To this day the town near that point is called Campaña, which in Spanish means "Bell," and on certain fiesta nights during the year it is said the solitary wanderer may sometimes hear it slowly ringing beneath the waters.

In return for the works of the Old World, Antigua sent the heavily ladened galleons with their precious freight to quench the ever quickening thirst of distant Spain, and so the buccaneers with an equally absorbing thirst, came that they too might plunder from the plunderer. Then the impregnable castle of Amoa was built upon the coast to guard the wealth so industriously garnered, and it is said that the King of Spain upon once being asked why he stared so intently through his telescope across the western waters replied: "I look that I might see Amoa, for truly it has cost enough to make it visible even from here."

Thus the years rolled by and royal governor succeeded royal governor, and new eyes looked from behind the window bars where other eyes had peered before at other cavaliers, for to all things animate and inanimate there comes a day that must—the end.

Long had the gods of the Quiche's slumbered, and men had forgotten these many years that once they were. Yet all this time they had stirred deep down in the heart of the other great volcanoes, and suddenly on a never-to-be-forgotten July night in the year 1773 they burst forth again in a mass of flame and smoke upon the sleeping city. Deep detonations shook the air, and the rumbling of the earthquake once more resounded throughout the land as the outraged gods strode with heavy steps across the trembling earth. Belching flames lit the crashing walls and scene of death—churches and palaces, the mansion of the rich and the hovel of the poor lay a crumbling mass. Priest and soldier, hidalgo and pauper alike were crushed beneath the fallen walls. That which the setting sun had viewed the proud mistress of thousands the sunrise found prostrate—but a pile of pitiful ruins. The gods of the Quiches once more had triumphed.

Yet again among the Spaniards other causes were assigned. It was said that there had been dissentions between the native brothers and the ones from Spain. Indeed so bitter had waxed the controversy that the civil authorities were appealed to with the result that certain ones of the Spanish brothers were publicly whipped. Therefore it was only a question of hours, said the wise, before the earthquake came to chasten the wickedness of man. Then, too, there had been scandals connected with the sisters at which men shook their heads—so fortunate, indeed, is it that professions do not make religion and that its true value is in no way lessened by the acts committed in its name or by those who seek its shelter.

Still who can correctly assign a cause for the great cataclysm, for did not Antigua gravely aver that a neighboring town had been destroyed because there was no bishop in the place at that time, and yet when her own end drew nigh she had no lack of bishops and of priests?

And so it came to pass that the early Spanish capital had been destroyed when the two volcanoes poured forth water and fire, and thus it was that the first was solemnly baptised "Agu" and the latter "Fuego," and taken with all formality into the church in the hopes that they would reform and eschew their heathen deities and evil ways. To this day both Agua and Fuego have faithfully lived up to their responsibilities, though Santa Maria, a number of miles to the north, in 1902 blew out her entire side and overwhelmed fincas and cities.

Many of the poorer classes even after the second catastrophe clung to their ruined homes and wished to trust to the conversion of the great volcanoes and live where they were born, but others there were who had less faith in the intentions of the new converts, and others still who owned property upon the site of what is now the City of Guatemala, for real estate was cherished in those days even as it is now. Therefore it was deemed expedient for many excellent reasons to move the capital twenty-four miles distant to the valley of the Hermita, where it now stands. The reluctant ones were dragged forth in spite of unavailing protests, and the remnants of their homes destroyed by the soldiery, that the new city might become great and powerful and perchance the values of certain properties be maintained.

So the city of Guatemala has grown at a safer distance from the great peaks of Agua, Fuego and Acatenango completely surrounded by deep barancas which it was hoped would deaden the earthquake shocks, until it again stands without a peer in all Central America.

Of Antigua itself many interesting ruins remain, for though it is now a town of several thousand inhabitants it is essentially a city of the past. The new lives but in the old. Everywhere above the lowly dwellings of to-day tower the ruined churches—vast, high arched and domed—with battered belfries in which the old bells still summon the worshippers to prayer in some improvised chapel in the ruins below. The vast majority are, however, roofless and tenanted only by the flickering shadows of the present, and the memories of the past. Where once swelling anthems pealed and proud hidalgo knelt in prayer, wild flowers grow in tangled profusion and creeping tendrils cling. Grass waves knee deep upon many a roof, and cloistered courts re-echo but the flutter of beating wings. Far down where the Inquisition flourished, the rat alone steals stealthily on its way or weird iguano creeps to light like some poor tortured soul. The dismal cell of monk or nun stares out upon the world with fallen roof and gaping doors, a feeding ground for the lowly hog.

San Francisco, the greatest church of all, contains behind triple bars in a little chapel within its walls the remains of the holy Betancourt, who in his day performed many miracles, they will tell you, and who, it is believed, will ere long be canonized. Pilgrimages are made to this shrine from miles around, the penitents going on foot to obtain the full benefit thereof. Then it is that Antigua assumes the air of the present, and is to be seen in her gayest garb, and that the shrine of Betancourt fairly bristles with small wax images of the man, woman and child, of the head, arm or leg which it is hoped will be cured.

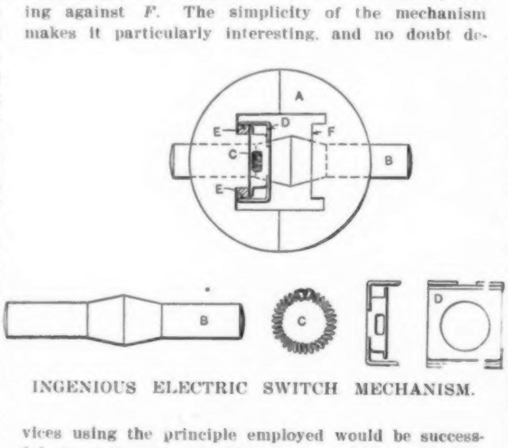
The Indians come from many distant villages, for now they have adopted the God of the stranger, though still the nagual lives for each, and far down, down in their hearts at times they feel the old gods stirring.

The fiesta summons them to the moss grown walls built by their ancestors, yet no longer are they slaves and no longer does the Spaniard rule throughout the land. What must be their thoughts as they cluster around their fires during the fiesta nights, who can tell? For after all the native gods in winning yet have lost.

And thus must we leave Antigua as the silent tropic moon shines down upon the scene of her ancient splendor—upon the walls of her crumbing churches and palaces bathed in the ruddy glare of the flickering camp fires of her former bondsmen, while through the dusk loom the sweeping outlines of Agua, Fuego and Acatenango—vast, silent and inscrutable—witnesses alike of her glory and of her ruin.

Ingenious Electric Switch Mechanism

The accompanying line engraving shows an electric switch mechanism, the interesting feature of which is the simplicity of its action. In the top view the mechanism is shown assembled, and below are shown the three main details, the casing *A* not being shown here. Disregarding the casing, the switch mechanism consists practically of only three parts: First, a push bar *B* extending clear through the switch, having its larger diameter in the center, and shaped conically from the center for some distance toward each end, as clearly shown in the illustration; second, a coil spring *C* which encircles the bar previously mentioned in such a manner that the axis of the spring forms a circle around the bar; third, a moving contact piece *D*, forming a casing over the spring. When this contact piece is in the position shown in the upper view, it is in contact and forms a circuit at *E*, the contact pieces in the casing *A* being shown cross-sectioned for the sake of clearness. The action of the device is simply this: When the bar is pushed forward the coil spring rides up on the conical surface until it reaches the center of the bar, all the time preventing the contact piece from releasing from contact at *E* until the spring has reached the central and highest part of the bar. At this moment it suddenly contracts and moves swiftly along the conical shape on the other side of the highest point of the bar, carrying with it the moving contact piece *B* and releasing it from its contact at *E*, bringing it against the other side of the casing at *F*. It is not possible to move the contact piece part way and let it slip back again, drawing an arc which burns the contacts and eventually destroys them. The contact piece must be either positively in contact at *E* or out of contact, resting against *F*. The simplicity of the mechanism makes it particularly interesting, and no doubt devices using the principle employed would be successful in automatic machinery for positive and instantaneous "knock-outs" and stops of various descriptions.—*Machinery.*



INGENIOUS ELECTRIC SWITCH MECHANISM.

Interesting Plant Discoveries

An agricultural explorer of the Department has spent the year exploring the plant resources of southwestern Asia. Among the large number of interesting things he has secured is a variety of alfalfa from Erivan, which is said to be longer lived than the Turkestan; a species of medicago from an altitude of over 4,000 feet, which is already being utilized in the work of creating new hybrid alfalfa for the northwest; a wild almond from the Zarafshan Valley, found growing on the dry mountain sides at an altitude of 6,000 feet; a drought-resistant cherry for home gardens in the northwest; and a collection of apricots with sweet kernels from Samarkand; the Afghasian apple and special varieties of pears for trial in the Gulf states; some remarkable olives, which have withstood zero temperatures and still borne good crops of fruit; late and early varieties of Caucasian peaches for trial in the southwest; seeds collected in the Caucasus from wild plants of the true Paradise apple, which is used as a dwarf stock for the purpose of obtaining seedlings not infected with crown gall; scions of a newly produced crab apple, reported to be a better keeper than American crab apples; the slew abrikose, a variety of apricot with a skin as smooth as that of a nectarine; a remarkable drought-resistant poplar for the middle west; and a wild strawberry, fruiting at the end of February on the dry calcareous cliffs of the Caucasus.

In view of the varying data published concerning the solubility of gold in nitric acid, F. P. Dewey has carried out experiments which show that gold is dissolved to some extent when treated with the boiling, highly purified acid. The method employed to determine the amount of gold in the strongly acid solutions is described.

Securing Efficiency in Railroad Work

Mr. Harrington Emerson on the Right Way to Do Things

The question of efficiency and economy in the management of industrial enterprises has of late been much discussed, both in the daily press and also in the more technical papers. One contribution to this subject, which commands immediate attention owing to its high character, its direct connection with work actually performed on a large scale, and, last but not least, the numerical examples, drawn from practice, with which it is illustrated, is a paper recently read by Harrington Emerson, the eminent expert, at the invitation of Harvard University. Early in 1904 Mr. Emerson was retained by the Santa Fé Railway to inaugurate and direct such reforms as might remedy an inordinate rise which had occurred in the running expenses of the railway during the years immediately preceding. The state of affairs which prevailed is well brought out in the following table showing figures collected from the president's annual reports:

	Cost per locomotive mile for repairs.	Cost of repairs per locomotive.	Number of locomotives.	New locomotives secured.	Cost of repairs per ton of locomotive, weight.
1897	$0.045	.....	.....	...	.....
1899	0.0558	$2,032	1,083	...	.....
1900	0.0592	2,096	1,136	...	.....
1901	0.082	2,858	1,174	52	.....
1902	0.0922	3,156	1,312	169	.....
1903	0.0867	3,042	1,309	130	$38.45
1904	0.1134	3,772	1,433	151	40.23
1905	0.1256	4,165	1,454	36	46.23
				538	

A diagnosis of the causes of this rise revealed a number of influences at work. Briefly stated, the problems which were confronting the company were of threefold character, namely: (1) Physical—to cope in prompt and adequate manner with the necessary repairs in shops which had become run down, which were mostly antiquated and manned with mechanical employees, most of whom were not only at the time striking, but were very hostile to the company. The enormous increase in business which was taking place at this time made it imperative to find means to make the best of the existing equipment, as it was quite impossible to build and equip new shops in time to take care of the increased deterioration of the overloaded equipment. (2) Financial—to check the alarming increase in expenses. (3) Moral—to eliminate radically and permanently the strain and hostility between employee and employer.

Before going on to point out more in detail some of the methods followed and results secured by Mr. Emerson in the attack of these problems, we will pause to consider some of the fundamental principles upon which his plan of campaign has been framed, principles which for their convincing simplicity and extreme importance claim our most careful attention and supreme interest.

One short sentence with which Mr. Emerson heads one of the sections of his paper expresses the essence of the fundamental principle which lies at the bottom of his method. This sentence reads, "Separate operations are often connected in dependent sequence." In exposition of the purport of this sentence, we can do no better than quote Mr. Emerson's own words. He says in part as follows: "Lifting a load is one operation, carrying it is another. If a path is so bad that a good man can only take half the load and walk only half as fast, his carrying power is reduced to one-quarter, through no fault of his own. Thus fifty per cent efficiency as to load and fifty per cent efficiency as to speed results in twenty-five per cent mile-pound efficiency. If the man is in addition slow and lazy, if, under any conditions, he moves at half speed and takes only half reasonable load, he will carry only a quarter as much and walk only a quarter as fast, so that the end efficiency is only 6.25 per cent, or only one-sixteenth of the standardized task. Grant a man-efficiency of 90 per cent, and a condition-efficiency of 80 per cent, hence a combined condition and operation efficiency of 72 per cent, and assuming operations averaging in two-fold dependent sequence, and the end result will be 72 per cent of 72 per cent, equal to 51.84 per cent. When an investigation shows an end efficiency of 50 per cent, it does not follow that the workers are as low as 90 per cent, or that conditions are as low as 80 per cent, since dependent sequences may average three, four, even five or six or more. Assume men at 100 per cent and conditions at 90 per cent, in six-fold sequence, and the end result is only 53.14. If all the operations in a shop average 95 per cent, the shop as a whole may average anything from 95 per cent down." It requires but a brief moment's reflection, once this matter is brought home to us, to realize with what avalanche power the losses due to even comparatively slight defects in the individual steps may rise in a process in which a large number of "dependent sequences" are involved. And obviously processes of this kind, in industrial and manufacturing work, are the rule rather than the exception. Furthermore, the improvement which can at times be effected in the efficiency of one single step in the sequence is sometimes vastly greater than anything that has been considered in the figures quoted above. For example, the cutting power of steel upon steel has, in the past, been improved from eight pounds an hour to 1,600 pounds, that is to say, the efficiency has been raised from 0.5 to 100 per cent. Dependent sequences are often as many as 50 in a series.

Passing on now from this exposition of the fundamental principle underlying Mr. Emerson's work, we proceed to consider a few instances which show how and with what success the principle has been applied to some concrete cases.

The first example which Mr. Emerson cites, as an apparently trivial and yet thoroughly characteristic step in the extensive reform which took effect at the Santa Fé Railway under his guidance, relates to the cost of maintenance for belting in the shops of the company. When Mr. Emerson's work began, it was found that this item, being regarded as of altogether minor consequence, was left in the care of no particular person, with the result, as will presently appear, that the efficiency in this department was execrably low. Remembering our fundamental principle, we dare not despise any attentions paid to this detail or any other, for belting is more important than it seems; it is a link in a chain. Every belt failure entails a dependent sequence of loss, as the broken belt puts machine and man out of commission, delays the work in progress, holds locomotives in the shops, prevents the moving of trains, lessens revenue in an endless "This is the house that Jack built" series.

For the year ending June 30th, 1904, the cost of new belting had averaged $1,000 a month, and belt failures had averaged 300 a month. By careful attention to the quality of belts purchased, and to the way in which the work of belt-repairing was being handled, these figures had been reduced by May, 1905, to $163 a month and forty-three belt failures, respectively. The above is merely one perhaps seemingly trivial example of the kind of progress that has been made in every department in which time has hitherto permitted the application of the economic principle illustrated. A large number of figures might be quoted to show this, but we must be contented here to pick out a few of the most striking. Probably the most extreme instance of the waste which may occur through neglect of the correct economy principles is the showing made under the heading "Fuel." This represents the largest item of expense on most railroads. On the Santa Fé the fuel paid for amounted to an average of 250 pounds for every thousand tons weight of freight trains per mile. Actually measured consumption on test runs of freight trains proved to be about 80 pounds instead of 250.

According to the *Erie Railroad Magazine*, for September, 1910, the average amount of coal used per mile by its passenger locomotives is 108 pounds. One division was selected for special supervision, and its average was soon brought down to 79.5 pounds per mile. One locomotive in this division was singled out for a six days' test, during which its coal consumption was reduced to 35.1 pounds per mile. A switch locomotive is reported by Mr. W. C. Hayes, of the Erie Railroad, in the case of which a fuel consumption of 2,088 pounds, under common working conditions, was in a test, with increased work, reduced to 720 pounds.

The great contrast between some of the figures taken from common practice and those obtained when proper care has been taken, is due to the ten links of dependent sequence between the coal mines and the ash pit. The ten links are:

Coal charged by the mine but not delivered to the car. Coal shrinkage in transit. Coal shrinkage in unloading. Coal shrinkage in bunker. Coal shrinkage in loading. Coal wasted in roundhouse, before locomotive takes train. Coal lost through wasteful firing. Coal lost in wasteful running. Coal burned while waiting on side tracks. Coal lost to ash dump, especially when fire is pulled.

Of one more department to which Mr. Emerson gave special attention we can here speak only very briefly, namely, the one to which we have referred at the outset as one of the three phases of the problem at issue, the moral phase. Mr. Emerson has shown most clearly that the best efforts are put forth by the men, the healthiest feelings on their part toward their employers are bred under a system of properly regulated "efficiency rewards." Perhaps no better evidence can be brought forth of the spirit thus engendered than by quoting the words of Mr. D. E. Barton, foreman of the Topeka shops of the Santa Fé Railroad, as he addressed the Railroad Foremen's Association: "The efficiency system is distinctly cooperative. It changes the men from half-hearted, listless, idle, indifferent workmen to striving, alert, active, intelligent, honest, self-respecting workers, who take an intense interest in the work at hand, and are willing to do whatsoever their hand finds to do with all their might." Numerically, the character of the bonus system, as well as its results, is brought out with great clearness in the following table:

	April, 1902.	April, 1909.
Passenger locomotives turned daily	6	7
Freight locomotives turned daily	18	13
Gross tons handled	77,742,800	152,430,860
Mechanics' wages per hour....	$0.375	$0.42
Average bonus per hour.......	....	$0.043
Pay roll	$16,813	$17,813
Bonus paid	....	$1,849
Number of men..............	260	223
Locomotive failures...........	57	11
Miles between failures (all)...	4,377	....
Miles between failures (passenger trains)	....	17,683
Miles between failures (freight trains)	....	29,995
Miles between failures (all)...	....	47,678

The last three items alone in this table, showing a total of 4,377 miles between failures in 1902 and 47,678 miles in 1909, after the reform had gone into effect, are enough to impress the most skeptical with the enormous importance and value of such methods as are advocated and taught by Mr. Emerson. We may well pause to consider what such reforms would mean to the individual and to the State if introduced, not in merely this or that branch of some single industry, but to entire systems, and to the whole industry of our country.

A New Impact Testing Machine

In a recent number of *Engineering*, Mr. R. D. MacLachlan describes a machine on the principle of a weight falling on a plate and applying an impact tensile load. With such machines it is desirable that the load should be applied directly, so that as little as possible of the energy of the falling weight is lost in the intermediate connections. In the machine described the plate which receives the blow is made very stiff and is screwed directly on to the specimen. Precautions are also taken to insure that the blow from the weight on the specimen is a fair one, and that there is no bending as well as tension stress on the specimen. The weight or tup is of cast iron, accurately turned to fit the central rod, and it weighs 82.04 pounds. It is raised by means of a windlass. A small key on the tup runs in a key-way on the central rod, to insure that there is no rotational motion of the weight when falling. The energy absorbed in fracturing the specimen is measured in two ways: (1) The velocity of the falling weight is measured; (2) the kinetic energy of the weight after fracture is recorded. The second method is not considered so satisfactory as that of measuring the change in velocity. Preliminary tests are recorded. A bar of mild 9/16 inch steel of commercial quality was selected. Test pieces were screwed ½ inch and turned and accurately ground to ¼ inch diameter for the middle 2 inches. The specimens were subjected to different heat treatments, with the object of determining the effect of such treatment on the power of the material to resist shock. In all cases the elongations due to impact testing are greater than those due to tension testing. Increase of temperature during annealing appears to reduce the total extension under the static load and the impact load. The effect of cooling the specimens in water is very marked, the elongation in both static and impact tests being much reduced. The preliminary tests showed that the measurement of the velocity on the drum of the chronograph was not satisfactory. A stroboscopic method has been adopted which is a great improvement.

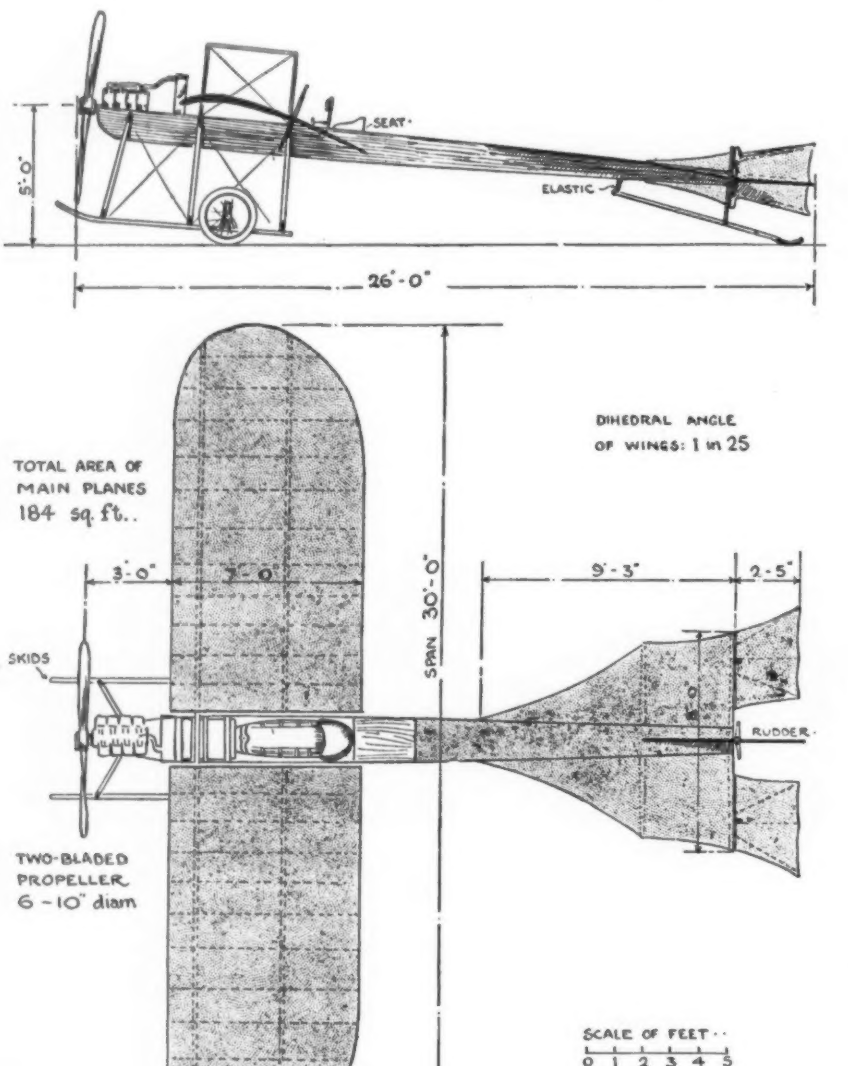
The Hanriot Monoplane

The Construction of a Remarkable French Flying Machine

Wherever it has been seen, the Hanriot monoplane has invariably attracted attention, and more often than not received favorable criticism of its shipshape appearance. And, now that it is about to be brought to the fore in this country under the ægis of a powerful syndicate, the interest that it has awakened in the capacity of a mere "visitor" at some of our flight meetings is likely to mature in a more practical form among those who have an ambition to fly. There are many points of distinct originality in the Hanriot design and construction, but it is not always that these features in question are appreciated individually as such by those on whom their *tout-ensemble* makes a good impression. First and foremost there is, of course, the wooden boat-shaped hull, that naturally strikes everyone at first sight as the outstanding departure from orthodox practice, but there is also the "A" type frame that supports this body upon the wheel and skid chassis, and those who attended the previous Paris Aero Show will doubtless remember that a similar feature of construction characterized the Hanriot monoplane of last year. It was one of the most interesting constructional details that this exhibition brought to light. Simple in design and construction, strong in principle, it formed a clever solution to a problem that it has not been easy to turn into a really neat job; that the method has been generally appreciated may be judged from the fact that several other makers of monoplanes subsequently adopted the essential features of this design.

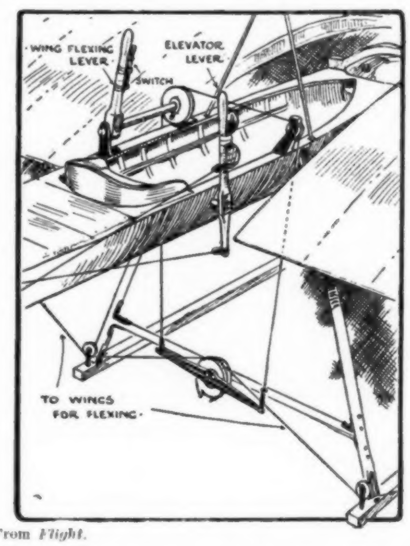
There is also a good deal to be said in favor of the boat body on the Hanriot monoplane, and quite apart from any intrinsic merit that this system of construction may possess on its own account, there is a distinct advantage in the system in that it dispenses with the use of a tremendous amount of wire that would otherwise be necessary for bracing some equivalent girder member. We have no objection to wire in principle, and unquestionably it is a wonderfully strong and light method of building up a frame; but on the modern aeroplane there is so much wire that any method of reducing the amount is welcome on this score alone. Wire bracing needs some little attention, for it should at least be periodically inspected, and if more wire is used than is absolutely necessary it seems to us that there is just the likelihood that it may provoke carelessness with regard to its proper maintenance. By the use of a boat body, the Hanriot monoplane is clear of all wire for which a suitable substitute can be provided, and those wires that do remain take on, in consequence, an added importance that should insure their proper attention. It may, perhaps, seem a little outside the zone of present day conditions to bring forward a criticism of this description, but it must, after all, be remembered that manufacturers essentially hope to obtain a fairly wide sale for their machines, and many aeroplanes are quite likely to pass into the hands of users who will not always realize the necessity of persistent attention to small mechanical points while their chief object is to get up into the air. The wider and the more rapid the development of aviation, the more is this likely to be the case—as it has been, for instance, in connection with motor cars—so that in considering the construction of machines, it is necessary, even now, to take note of features such as these, because of the influence that they may have on future design.

The boat body of the Hanriot monoplane is constructed on the lines of a racing skiff, and it is well known that this form of construction produces a very strong and very light girder. The top of the body is entirely decked in, except for a little cockpit containing the pilot's seat. Immediately behind the pilot's seat the deck is thickened so that it is safe for the pilot to stand thereon when mounting and dismounting. No wires of any description interfere with free access to this part of the machine. Three steel strips form a kind of cradle for the support of the body on the "A" type chassis frame, the strips being bolted to the inclined struts of the frame and passing under the body as shown in one of the accompanying sketches. Steel strips are also employed for lashing the main spars of the wings to the body, and it will be observed in the same sketch how these spars are mounted on blocks and lashed in place as described. The spars are not horizontal, but are set at an angle to one another, the "dihedral" being 7 inches, that is to say, the extremities of the wings rise 7 inches above the shoulders. The spars in question are 3 inches deep and 1½ inches wide, and they are constructed on the three-ply principle instead of being cut from one piece of wood. This is a departure from common practice that we have not noticed elsewhere, and in view of the criticism that has been levelled against the supposed tendency of monoplane wing spars to buckle, this method of construction will doubtless arouse interest. The laminæ of the spars are arranged vertically, but again bearing in mind the matter just referred to, it is conceivable that some use might be made of this principle with horizontal laminæ to strengthen the spars against the forward pressure; it is the end thrust on a machine that is the difficult force to meet. The vertical forces can be more readily provided for because the presence of the propeller in no way interferes with any system of bracing that may be preferred. In the Hanriot monoplane it is worthy of note that the rear spars of the main wings are individually trussed by a diamond bracing, each spar being fitted with a vertical cross strut in the center and the four extremities being tied by diagonal wires. The rear spars are hinged to the frame so that they can rock for wing warping, and the hinge pins are tied together by a steel tube so as to relieve the body of undue strain.



From *Flight*.

THE HANRIOT MONOPLANE, 1910



From *Flight*.

DIAGRAMMATIC SKETCH ILLUSTRATING THE SYSTEM OF HAND CONTROL ON THE HANRIOT MONOPLANE

A pivoted foot-bar, not shown, operates the rudder.

The control of the Hanriot monoplane is mainly interesting on account of the use of two levers, one under the control of the pilot's left hand and the other under the control of his right hand. That on the left moves sideways and operates the wing warping, that on the right moves to and fro and controls the elevator that forms a hinged extension of the tail plane. In front of the pilot's seat is a pivoted cross bar that can be rocked by the pressure of his feet. This controls the rudder, which is mounted between the halves of the elevator. The fixed tail plane on the Hanriot monoplane is quite flat, and consists of a sheet of fabric tightly stretched by the aid of a couple of transverse spars. The rear portion of the tail plane is deflected a little below the line of the leading portion, to which it has a relative, although small, angle of inclination.

Well forward of the main planes is the engine, which on this machine is an 8-cycle 40-horse-power E.N.V. This is mounted in the bows of the boat body, and is also partly supported by the struts of the "A"

frame, a pair of which are situated immediately beneath the motor. The tractor-screw, which is direct driven by the engine, is 2.1 meters in diameter and 1.2 meters in pitch. When at rest on the ground, the machine is carried by a pair of pneumatic-tired wheels in front and by a light trailing-skid behind. The wheels are mounted on a steel axle that is reinforced by a wood batten and mounted in vertical guides, so that it has a considerable upward travel. Suspension is effected by elastic springs anchored to the main skids and attached to the upper end of a column that rests upon the axle itself.

Working Distances of Wireless Stations

Methods by Which Efficiency is Obtained

By W. C. Getz

In looking through the technical inquiry portions of this and contemporary magazines, the reader will find invariably that fully 75 per cent of the questions asked about wireless telegraph are of the "How far will it work" type. At first glance this may seem a logical question to the uninitiated, but upon a moment's reflection the utter worthlessness of any stereotyped or

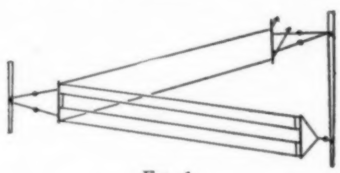


Fig. 1

cut and dried data based on such insufficient information as the height of the aerial or capacity of the spark coil, without a detailed knowledge of the operating conditions and environment, is easily apparent.

While heretofore the editor has probably answered these questions basing his deductions upon performances of similar apparatus that has come under his observation during his greater or less experience in the wireless field, it is now time to bring to the attention of the experimenters, and particularly to the young amateur who has an extremely limited knowledge of electricity and who is therefore more greatly imposed upon by irresponsible firms, the futility of such inquiries and subsequent answers.

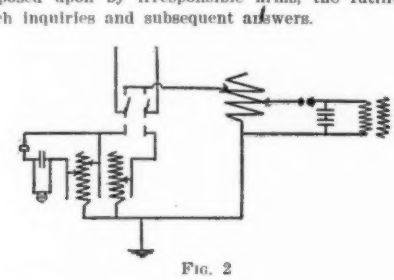


Fig. 2

Such questions as these, while asked in good faith, cannot be answered any easier than a hypothetical question recently asked the editor of a photographic journal—the party writing wishing to know if the editor considered a man weighing 180 pounds, and owning a dress suit, competent to lecture on "Color Photography," without the editor ever knowing any more about the man than was stated in the inquiry. Individual conditions alter all cases, and it is the purpose of this article to show the great many conditions that enter into the subject of wireless telegraphy and which, unless carefully studied and complied with, may greatly alter the results from what was expected.

Fig. 3

The efficiency of a wireless station depends on the following general points:

1. System or "hook-up" used.
2. Locality of station.
3. Height of aerial.
4. Capacity of aerial.
5. Sensitiveness of apparatus.
6. Intelligence and care used in connecting and adjusting the necessary apparatus.

Each and every one of these points will cause a difference in the working distance of a station, and as it is hardly possible that there are two stations exactly alike in all of the above points, it is therefore manifest that no formula or rule can be derived that will cover the effective range of any and every station.

A brief discussion of some of the above points may serve to enlighten the experimenter on certain details which may be the cause of some inefficiency of the particular station in which he is interested.

The system or wiring diagram used causes more controversies than any other of the above points enumerated. Fundamentally, every wireless circuit contains a variable or constant inductance, and a variable or constant capacity. Various combinations of these have been evolved into different systems, each so-called "system" having its stanch adherents, who set forth claims of unexcelled superiority in "selectiveness," "long distance," etc., that may be really due to a fortunate combination with the local conditions in any particular case. It is well known to the majority of experimenters that certain "hook-ups" seem to work better at one station than at another, and as no rule can be assigned to cover this, the experimenter getting the best results is usually the one who is not content with one diagram, until he has thoroughly tried out

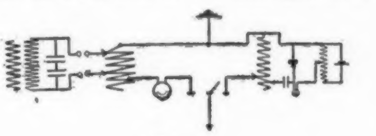


Fig. 4

all. Such diagrams have been issued both in book and blue print form for the past year and a half, and the amateur who neglects obtaining the best and most recent copies of these diagrams is usually the one who never has "results" with any apparatus.

In considering the second point—the locality of the station and its effect on the working distance, we must depend upon the experience of others and base our assumptions accordingly. On water, it is conceded that wireless can be worked over twice the distance for a given equipment than can be done over land. While nearby mountains do not cut out the waves as was first assumed, it often happens that in mountainous regions a good ground is hard to obtain. And again, ore-bearing mountains, if near at hand, in some instances have noticeably reduced the efficiency of a wireless set, especially where the ore is of a magnetic nature.

Fig. 5

Water itself does not always form such a good ground, as the resistance of clear water containing mineral or vegetable residue is very high. The best ground is a copper plate or wire netting placed in loam that is permanently moist. A ground plate buried in clay is usually inefficient, and sand, unless wet, has a very high resistance. A station in the woods will lose much of its transmitting energy if the aerial is near any trees. For this reason, when it is necessary to guy the antenna to trees, strain insulators should be cut into the guy wire at equidistant intervals to reduce this leakage factor.

Where static is prevalent the receiving efficiency is somewhat decreased at times owing to the inability of the operator to read through static. By shunting a variable condenser around the detector this annoyance may be greatly reduced, but at the expense of receiv-

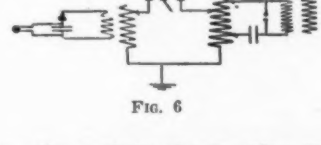


Fig. 6

ing radius. The proximity of power wires sometimes causes electro-magnetic induction in the receiving set. The use of the "loop" form of aerial greatly eliminates this trouble.

The height and form of aerial also varies the distance of operation. There is no rule governing the relation between the aerial height and the effective radius of communication, although Marconi at one time stated the distance was proportional to the square of the height of the antenna, for a given set. This, of course, does not hold good with the present

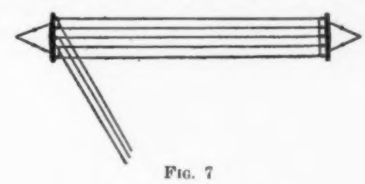


Fig. 7

type of wireless apparatus, as the instruments now on the market have many times been successfully used over distances one hundred times greater than the aerial height squared.

The main consideration is to have the aerial perfectly insulated. The number and size of the wires used in the antenna depend entirely upon the capacity of the station. When a brush discharge is observed from the aerial, it is generally a safe sign that more aerial wire is required.

The form of aerial, whether straight "cage," "flat top," "loop," "umbrella," etc., can only be determined after a thorough trial is made of each and the results classified so that the one giving the best results for the individual and particular station is ascertained. The capacity of the aerial varies according to the different forms and dimensions used.

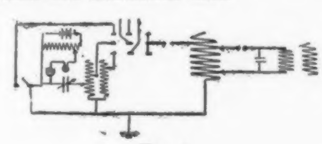


Fig. 8

The relative sensitiveness of the instruments used is a subject that the writer would like to omit, as there is bound to be a difference of opinion on the same, and this is intensified by the fact that every manufacturer differs radically in certain designs, and each has an abundance of testimonials to show that his is the only right and efficient way. However, the writer has tried to take a view of strict impartiality, and trusts that if he unknowingly wrongs any one they will write and inform him of the case. As there are now several score concerns making and selling wireless apparatus, and thousands of amateurs are also making their own instruments, certain well known and standard types will be discussed, and the experimenter may govern his conclusions in proportion to which his instruments approach these standards in efficiency.

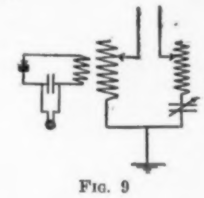


Fig. 9

It is not to be supposed that an instrument costing but a few cents will give as good results as a well made and reasonably but higher priced instrument. For instance, the so-called silicon crystals sold to experimenters by some wireless concerns will not give 50 per cent of the efficiency of the improved silicon detector, which is designed and tested for sensitive work. The crystals in the latter are selected from specially imported silicon, and many lumps are rejected before a sufficiently sensitive piece is found. In a like manner the efficiency of any other instrument depends upon the sensitiveness of the individual instrument itself, more so by far than on the type of instrument.

On the receiving side the detector is the vital part of the set, without which it is impossible to operate.

In the order of their sensitiveness, the following types of *standard* detectors have been classified:

Class A. Electrolytic (silver plate wire, 0.0001 inch / 0.00002 inch) perikon.

Class B. Silicon (improved) pyron. Ferron.

Class C. Molybdenite.

Class D. Carborundum. Magnetic. Electrolytic (silver plate wire, 0.001 inch / 0.0001 inch).

Class E. Carbon and steel. Aluminium and steel. Coherers, etc.

The Perikon detector is the most extensively used type for sensitive work, as it may be easier adjusted and kept in adjustment than any other used in practical work.

The telephone receivers should be of high resistance with a maximum amount of ampere turns per ohm resistance. In this respect enamelled wire is far superior to silk insulated wire, and a number of progressive firms are following in the track of the writer, who had used enamelled wire for receiver windings for the past several years. Low resistance receivers are of no use whatever for sensitive work.

The tuner may be of the inductive type, or of the familiar "auto-transformer" or single winding type. The latter may have one, two or three sliding contacts. It has been the writer's experience that excellent results were always obtained with the double sliding enamelled wire on tuners, the writer has used a number of tuners wound either with bare, enameled, or cotton insulated wire, and he could not notice any marked difference in the respective efficiencies.

Condensers should have about from 0.001 to 0.005 M.F. capacity. The potentiometers should be at least 300 ohms resistance, when two or more cells of battery are used.

On the transmitting set, the relative efficiency of the induction coil or open core transformer and the closed core transformer seems to depend upon the reliability of the builder. Both work well when properly and intelligently used. Where only direct current is available, it is not advisable to use the Wehnelt interrupter, as it gives very poor results on wireless work. By no means use it on alternating current, as the best results are obtained when the primary is connected direct to the A.C. mains, suitable resistance or impedance being inserted in series if necessary.

The sending inductance, spark gap, and transmitting condenser can be of any make that uses the general proportions of the standard types. The wire of the sending inductance should not be on less than a three-inch radius, and should be No. 14 B. & S. gage wire or larger. The spark gaps should have electrodes of zinc, or of some other approved alloy containing a sufficient amount of zinc to produce the char-

The adjustment and tuning of the transmitting apparatus really is the hardest part for the experimenter to accomplish. It means that he should try constant changes of his inductance and capacity and compare the readings of his hot wire meter in the aerial leads with the distinctness in which surrounding stations are able to receive him. If this is done in a systematic manner, each receiving station making a record of the clearness, and condition of spark, etc., thus being noted, the actual tuning may be easily and accurately accomplished.

A small power station tuned properly will probably work four or more times as far as one of double its power, but not in tune. The main consideration is to know what you want to try, and then to try it in the simplest and most systematic way possible. The personal element of good judgment and care in making the connections good is more responsible for some of the record results accomplished by certain experimenters than the type of apparatus employed.

The following information has been prepared for the use of the experimenter who wishes data on some stations that may have conditions somewhat similar to his particular station, and while this is only compiled from the operation of certain particular stations, the facts may be of use in "doping" out the probable results of apparatus that is to be installed. The ex-

							RECEIVING INSTRUMENTS							TRANSMITTING INSTRUMENTS							
Example No.	Local Conditions	Ground	Atmospheric Conditions	Height of Mast	Type Aerial Sketch No	Diagram No.	Detector	Tel. Rec.	Tuner	Condenser	Potentiometer	Battery	Receiving Radius	Coil or Transformer	Inductance	Condenser	Spark Gap	Source of Power	Watts used	Transmitting Radius	REMARKS
1.	On Hill 3 miles from Tide Water	To City Water Mains	Static in Summer	40 ft.	Fig. 1	Fig. 2	Silicon (Improved)	2, each 1,650 Ohms No. 40 Wire	1 Single and 1 Double Slide Tuner	.002 M.F	None used	None used	.300 miles	1 in. Spark Coil	No. 12 Wire 5 turns 18 in. Diam.	Leyden Jars, 2 each 6 x 2 in. Diam.	Zinc ¼ in. Electrodes	Storage Battery	200	10 to 15 miles.	Tuning Good
2.	On Rocky Hill 500 feet from Water	Poor Copper Plates in Sand	Good No Static	100 feet (iron)	Fig. 3	Fig. 4	Perikon	2 each 2,000 Ohms	Double Slide Tuner	.006 M. F.	270 ohms	1 Cell 1.1 Volt	350 miles	1 K.W. Open Core Trans.	No. 6 Wire 12 turns 10 in. diam.	26 Plates each 10 x 12 in.	Zinc ⅛ in Electrodes	110 Volt A.C.	1100	35 to 50 miles	Metal Mast—absorbed energy greatly.
3.	On Rocky Land 1 mile from River	To City Water Mains	Good	60 feet	Fig. 5	Fig. 6	Ferron	2 each 1,600 Ohms	Inductive Tuner	.004 M.F	None used	None used	600 miles	1 K.W. Open Core Trans.	1-10x1-2 in. Strip Copper 20 turns	20 Plates 8 x 10 in.	Zinc ¼ in. Electrodes	110 Volt A.C.	1200	40 miles	Transmitting side not well tuned.
4.	In Country near Woods	To Pipe in Well	Static Prevalent	80 feet (2 Trees)	Fig. 7	Fig. 8	Electrolytic .0011 in. 1.00002 in. Wire	2 each 1,000 Ohms	1 Single and 1 Double Slide Tuner	.0001 to .010 Adjustable	350 ohms	3 Cells Dry Battery	850 miles	¼ in. Spark Coil	No. 8 Wire 20 turns 12 in. diam.	10 Plates 6 x 8 in.	Brass ⅛ in. Electrodes	Dry Battery 8 cells	60	15 miles	Tuning of transmitting side excellent.
5.	Near City 10 miles from River	Moist Earth in Cellar	Good	50 feet	Same as Fig. 1	Same as Fig. 4 Rec.	Electrolytic and Silicon (Low Grade)	2 each 200 Ohms	Double Slide Tuner	.004 M.F	Graphite Rod	3 Cells Dry Battery	20 miles at greatest	1 in. Coil	None used (Untuned)	None used	Brass Balls ⅛ in. diam.	12 Fuller Cells	100	¼ mile	Poor instruments, no tuned trans., and careless adjusting. Used properly, would work better.
6.	In Valley near Bay	Moist Earth	Fair	15 feet	Same as Fig. 1	Fig. 9	Perikon	2 each 1,600 Ohms	Inductive, also 1 Single Slide Tuner	Adjustable .006M.F. and 1 Fixed	None used	None used	370 miles	No Transmitting Apparatus							Extremely selective. Intelligent adjusting. Careful experimenter.

contact tuner. The use of a third sliding contact is now being advocated by certain manufacturers who claim better selectivity with the same. The inductive type of tuner is considered to be the most senstive.

Apropos of the discussion now being waged among the several manufacturers regarding the use of acteristics that accompany the use of the zinc gap.

The current supply for the transmitting side should always be sufficient for the maximum amperage required by the transformer or coil when operating, in order that the spark may be maintained smooth and regular.

perimenter is again cautioned that his results may differ widely from those given herein, and that the only way to get the best results is to experiment with as many "hook-ups" and instruments as you can, until the happy medium is obtained.—*Electrician and Mechanic.*

Our Soda Lakes

Freaks of nature, aside from their importance to the scientific world and as curiosities for the vast army of sightseers to gaze upon, sometimes afford humanity a source of supply for many of the necessities of life. The latter is true of the Soda Lakes of Nevada, or, as they are locally called, the Ragtown Ponds. The waters of these lakes are strongly alkaline and, as their name would imply, contain large quantities of soda.

It should be mentioned that there are but two of the lakes. The larger covers an area of 270 acres, its greatest dimensions being about a half mile wide by three-quarters of a mile long, while the other is considerably smaller.

Aside from the make-up of their waters, the right to class these lakes with the freaks of nature is based also upon the fact that there are no visible streams tributary to or draining them, their entire water supply, except the small amount derived from direct precipitation, being supplied from subterranean sources. A study of their formation and water supply has been a theme for scientists during the past half century. Some claim that the Carson River is the source of supply. The bed of this river at its nearest point, which is some two miles distant, is fifty feet above the surface of the lakes. These bodies of water themselves occupy two circular depressions in the earth which geologists claim to be craters of extinct volcanoes, and it is said that the water from the river reaches these craters by percolating through the intervening earth, the mineral matter contained therein being unquestionably derived from the deposits of its subterranean passage.

These phenomena lie but a short distance off the old cross-continental trail, used by the forty-niners in their mad rush to the gold fields of California, and are situated right in the heart of the Carson Desert. The nearest town to these lakes is Leetville, but in the days gone by it was known as Ragtown.

Nestling in the banks of these strange lakes, indeed within a few feet of their very edges, are to be found springs sending forth continually streams of the purest cold water, free from any taint of soda or alkali. Had the early pioneers known that such an elixir of life flowed in that deathlike place how many lives might have been saved.

The rim of the greater lake rises eighty feet above the level of the desert, but so gradual is the slope that one approaching is not aware of the existence of such a body of water until the very brink is reached. Standing on the rim, for it can hardly be referred to as a bank, one gazes down at the glass surface of the salty water one hundred and sixty-five feet below. In early days these lakes were believed by many to be bottomless, no doubt a belief that still exists among a certain class. Of course, every body of water must have a bottom, and careful measurements have shown the greatest depth of these bodies to be in the neighborhood of a hundred and fifty feet.

The manufacture of soda from the waters of these lakes was begun a good many years ago, and is carried on by the simple process of evaporation. It is estimated that the two bodies contain more than a million tons of soda—enough to supply the whole world for a good many years to come. Time was when ocean plants supplied the raw material for soda, and it was the French Revolution which effected the first great revolution in the making of that necessary article of every-day use. When France was isolated from the world, her eminent scientists were called on to save the country from a threatened soda famine, and as a result Leblanc invented his process for the manufacture of soda from coal, lime, salt and sulphuric acid.

The Asiatic Brick

We should hardly expect to learn much of the arts of civilized life from the tribes of Central Asia, yet, it seems, they make better brick than we turn out. The barbarians employ the same material that we do, and, curiously enough, the thing that imparts superiority to their process of brick making is one of the most powerful agents of western civilization—steam.

When the Asiatics have baked their bricks for three days, the opening of the oven is closed with felt which is kept wet, so that the bricks still intensely heated are enveloped in steam.

The process causes a remarkable change in the character of the bricks. From red they turn gray, and at the same time acquire a remarkable degree of toughness and hardness. Although porous, they give out a sound, when struck, like that of clink stone; and they are said to resist the effects of weather much better than do the bricks of Western make.

Necessity was the mother of invention in this case, for the climate in which these ingenious Mongols live is subject to great extremes of temperature, having a disastrous effect upon bricks made by the ordinary process.

Our Typhoid Streams

A Problem of National Importance

By H. de Parsons, M.E.

The pollution of our streams by sewage and trade wastes has become a national issue. As the population increases, especially the congestion in our cities, the subject is one of vital interest to the well being and public health of our States. Changes produced by settlements have created new conditions. Some of these new conditions it is neither possible nor desirable to check, but there is no good reason why one community should misuse a stream to the detriment of another. The economic rank of a country is based on its natural resources. Of these resources, her rivers and waterways are foremost. Where can a rich and prosperous country be found which is not well watered? Sewage has to be taken away from the places of generation. Its manurial value has not been equal to the cost of securing it. Therefore, municipalities construct sewers so as to dispose of the sewage by water carriage, with the object of putting it out of sight as quickly as possible. As a natural sequence, sewers are built to operate by gravity and to discharge into the nearest convenient stream or body of water, so that the sewage may be diluted and carried away with the currents without further attention. The result is that some of our rivers are not now sufficient to provide proper dilution, and towns are drinking their own or other's sewage.

Philadelphia drank its own sewage before it began to filter the water supply from the Delaware River, and dearly paid the penalty in a high typhoid death rate. The supplies of many private water companies are polluted, and towns are refusing to accept the polluted water offered.

The author examined a water shed in New York State where the drainage from a village emptied into the reservoir supplying potable water to adjacent towns. Again, in Illinois, the water supply for a city was taken from some small brooks and rivulets into which all the adjacent farms with their out buildings emptied their liquid wastes. In this case the only effort at purification was a slight aeration of the water by being sprayed over an artificial dam in the reservoir. Again, in Wisconsin, a city was without a municipal water supply, and each house had a well in its back yard. These houses drained their sewage into open cess pools located in the same yards.

Albany filters its water, but even so its typhoid death rate is above the average of cities located amid clean surroundings, and its sewage is passed down to other places below on the Hudson.

The Ohio River is said by the Sanitary Commission of Ohio, to be polluted and unfit to drink, and yet it is the only source of supply for the territory lying along its banks in that State. Cincinnati drinks Ohio River water and discharges its sewage into the same stream for the use of others on the water shed below. The Ohio flows down past Kentucky. Covington and other places in this State drink Ohio River water.

The government is constructing dams in aid of navigation, and in many instances these dams are located without reference to backing up sewage-polluted waters into the intakes of water-supply systems.

The sewage discharged from one district flows to the next district below on a stream, and the process of getting rid of the sewage by dilution is not always safe nor final. Sickness, caused by germ life in the sewage, may readily be brought back to the upper district by intercommunication of the people.

It is a mistaken idea that a polluted stream will purify itself. If the current is rapid the process of purification will be more energetic than when the current is sluggish. But even rapidity of current is not to be relied upon as a safeguard. The Niagara River is certainly rapid enough, but still the town of Niagara Falls has more than its proper allowance of typhoid. The distance between the point of discharge of sewage and the point where the germs are taken up is not so important as the *time* of transit. If the current be swift, the distance that the germs will travel may be very great, as some disease germs have been proven to have comparatively long lives. The pollution of streams by sewage is an active agent in the extinction of human life, and drains the wealth of a community as successfully as the sewers do the houses.

The question of pollution has become a national one, since many of our most valuable streams are interstate in their flow. A village, town, or city, when so situated as to receive the pollution created in another State, is nearly helpless to aid itself. Some hold the opinion that the method of disposal of sewage is a local question to be settled by each community. This opinion is not well founded. Pathogenic micro-organisms are not local. People are not localized, but travel back and forth. Contagious and infectious diseases are not local. Disease caused by sewage discharged from one community may break out in another community and be brought back to the first community.

Although the pollution of streams is not a local question, the laws regulating sewage disposal should not be to drastic. They should encourage, rather than force, communities to prevent pollution, and should

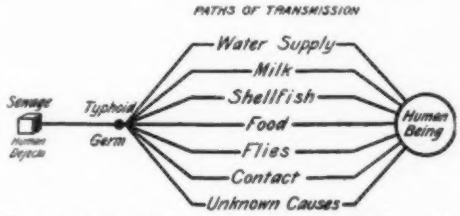


Fig. 1.—Paths Along Which Disease Germs May Travel From Sewage to Human Beings

be carefully drawn to fit all kinds of local conditions and be made to keep pace with the advances of sanitary engineering. A mode of disposal which is suitable for one place may be quite useless in another. We should not wait for an epidemic to learn our lesson. We need a special authority in health matters and universal co-operation, freed from all bureaucratic methods and amenable to scientific advance.

Sanitarians have much to learn. Our knowledge about disease organisms is still very limited, and in view of our ignorance it is certainly unwise to discharge crude sewage into many of our streams. Engineers should not erect structures, the strength of which they cannot calculate. Then why should they plan sewers to discharge into streams which may produce effects they cannot estimate?

The sewers of our cities are the place for every kind of germ, harmless as well as pathogenic. The sewers discharge them into the streams. At first, the bacteria diminish rapidly in numbers, and then the numbers diminish slowly. In the diminished numbers we do not find safety It is the weaker bacteria which perish first, the stronger ones live longest. Hard particles of sewage break up and liquefy slowly. These hard particles may carry bacteria in large numbers for a long time. It is a case of the survival of the fittest, and of those best protected by coatings of sewage origin. The typhoid bacillus, as well as other dangerous micro-organisms, pass the sewers to our streams. The most virulent survive.

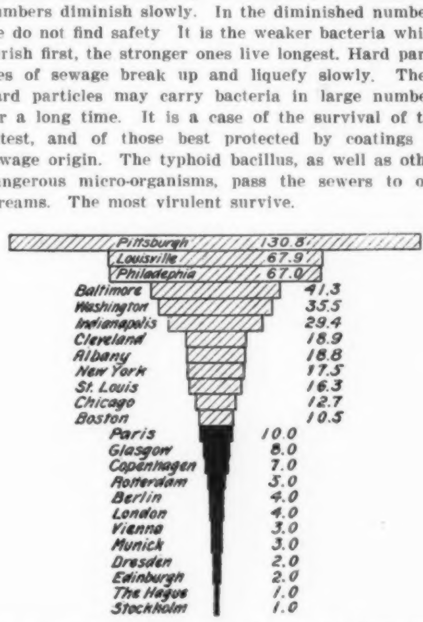


Fig. 2.—Typhoid Death Rates per 100,000 Population

Bacteria occupy a position in the economy of nature, as the lowest known order of life in the vegetable kingdom.

The real danger from pollution of streams is the scattering of germs. The sources of infection are water supply, milk, shell fish, food, flies, contact and unknown causes. Of these seven paths, along which the disease germs may travel from sewage to the human being (see Fig. 1) only one is guarded by filtering a water supply. The other six are left open. It is, therefore, reasonable to state that conditions should be maintained at the sewer outfalls which are inimical to germ life, so as to reduce their numbers to a minimum. This would place a barrier across every path of transmission.

When disagreeable things occur which are appreciable or apparent, our æsthetic feelings are shocked. But when similarly disagreeable things are not appreciable or not apparent, they often pass unnoticed. Thus people will go to theaters and into crowded halls, and breathe over and over the same air which others have emitted. They make little objection because they cannot see the particles of hair, skin, bacteria, and other things they breathe. It is the same with pollution by sewage. They throw it out of sight as quickly and as cheaply as possible, without any attempt at purification, and they often eat and drink it again unseen. Yet these same people are so cleanly in their habits that they would refuse to wear the unwashed underclothes even of a friend, to say nothing about wearing those belonging to some person ill with a disease. It seems perfectly reasonable, therefore, that we should guard the discharges from our sewers and protect our streams, so that there would be the least risk of causing sickness from drinking or eating our own or others' pollution.

Typhoid fever is a germ disease. The bacilli may come from milk, food, flies, or contact, as well as by water. The infection is traceable to sewage, and the sewage is scattered on water borne in the streams. It is a closed cycle, disease germs in sewage—sewage in water—disease germs in man. It makes little difference how many intermediate stages or steps there may be, the result from first to last is the same. The autumn months are often called the typhoid season, although typhoid as a disease is independent of the divisions of the year. Typhoid is a country disease. During the later part of the summer the streams are low, following the dry season, and the sewage is not properly diluted, and is often washed up on the banks and deposited in the shallow pools. People returning to the cities after their vacations bring back with them the typhoid germs, and through lack of careful nursing and neglect of ordinary precautions communicate the disease to others.

As a rule, the sanitary conditions existing in European summer resorts are much better regulated by the authorities than in America. Tent colonies and segregations of little bungalows and cheap shacks, so common in the vicinity of American cities during the summer, are frequently fine breeding places for typhoid and intestinal diseases. A comparison between the typhoid death rates in American and in European cities in countries where pollution is restricted, is remarkable and greatly to our discredit. It does not appear that we are a dirtier people than Europeans. The difference in the typhoid rates, therefore, is due to our careless handling of sewage. Some present typhoid death rates are shown in Fig. 2, and the numbers are the deaths per 100,000 population. In England there is a Royal (temporary) Commission on Sewage Disposal which acts as an investigating body and as a central authority which can assist all local boards. The whole subject has been closely studied since 1858, and a number of royal commissions have been appointed to aid the country. Prior to this date the rivers were grossly polluted, and many local nuisances had arisen. Out of the Public Health Act of 1872, joint committees or boards were formed from authorities bordering on specific rivers. These river boards regulate the pollution allowable in their respective rivers, and there exists a certain amount of co-operation between them. The work so done has been of untold value to England, and the knowledge and experience collected of the greatest assistance to the world. Thus for over half a century England has had some form of universal system.

In Germany similar ideas are being urged and put into practical operation. Each important water shed is guarded by its sanitary authority. Generally speaking, German rivers are larger than English rivers, and this has been an advantage, as it has delayed the condition of gross pollution. On the other hand, German rivers flow through several States, and since 1899 there has existed an Imperial Council of Health which acts like a central body to which the States can appeal. This may be considered as a preliminary step toward the formation of Imperial River Authorities.

In France systematic control of the pollution of the rivers is less advanced than in England or Germany.

In America there is no universal restriction of any general value in regard to sewage disposal. Our streams are now so polluted that it is practically necessary to use only purified water in our cities. But even in our cities where the water is filtered or

otherwise purified, the death rate is still higher than the rates in European cities. Filtering a water supply only closes one path for the typhoid bacillus to pass from sewage to man. It does not protect the suburban or country districts which use unfiltered water.

There are many cases of mild typhoid which do not incapacitate the patient for work. Any one of these walking cases may give typhoid to another who is in a receptive state. Also, many typhoid convalescents are allowed their freedom, who are still competent to communicate the disease. As a result there can always be found residual cases of typhoid which can only be traced to unclean habits. The pollution of our streams is largely responsible.

As so many of our rivers and drainage areas are interstate, it is necessary to have some national authority. States cannot sufficiently deal with the questions of pollution as there exists in them such a diversity in laws and regulations. Co-operation is wanted among the States, and this can best be secured by having the assistance of the federal government, that there may be less ignorance and uncertainty as to the mutual obligations of the States. Let the government be the central authority through a properly organized bureau. Let each State attend to its own work, under the standard set by the government. In this way the government bureau becomes the authority to which appeals can be made by the States and through which misunderstandings between States can be settled. A national association for preventing the pollution of rivers and waterways has been organized by a number of citizens of different States, all of whom are interested in sanitary science. These gentlemen are carrying on the work for the public good at their own expense, with the object of conserving the nation's greatest asset, namely, pure water. It is their object to have the federal government make a study of the question, with the hope that the laws of the different States may be made more uniform, and that the States may be made to cooperate more closely than they do at present so as to preserve the public health. There is surely truth in the saying that "He who cures a disease may be the skillfulest, but he that prevents it is the safest physician."—*Stevens Indicator.*

Electrical Notes

An Important German Electric Road.—The Dessau-Bitterfeld electric section of standard gage railroad is one of the most important in Germany. After equipping the section it now remains to adopt the best types of electric locomotive, and several firms have built locomotives for this purpose. The first ones to be tested are of the Siemens-Shuckert make, and are designed for express trains running at 60 miles an hour. The first trials of these locomotives were made not long since in the presence of an official commission including government delegates and engineers, and they expressed themselves as very well satisfied with the results. The present locomotives will draw trains up to 380 tons weight.

The Electromagnetic-gun Idea.—The thought that the giant power of a great electromagnet might be utilized to shoot a heavy projectile from a gun has occurred to many inventors. Some years ago Birkeland, whose apparatus for extracting nitrogen from the air is now in successful operation throughout the world, calculated the power that would be needed for such a cannon, and later an officer of the Austrian army made independent calculations with similar results. It appears that, to throw a projectile of about 90 pounds weight at a velocity of 500 meters a second, a current energy of 54,300 kilowatts, at 181 volts, would be required. But the energy is needed only for a fraction of a second. Birkeland proposed to obtain it by shooting a powerful electromagnet through a set of coils by means of an explosion, but Spacil, the Austrian officer, has ventured the opinion that the best way would be to move large coils at a very high speed in a rectilinear direction. Not much faith, however, is placed upon the practicability of such a gun.

A Mercury-tungsten Arc Lamp.—Messrs. Urbain and Feige of Paris are experimenting with a new form of arc lamp which uses an arc between mercury and tungsten. The arc is made in a vacuum or in an inert gas inside a suitable bulb. It was already known that a mercury vapor lamp could be made by using mercury with an iron electrode opposite it, so that the vapor produces the light and the iron remains cold. An arc is not formed in this case. When we wish to make such a lamp burn as an arc lamp, the iron is brought very near the mercury, about one-eighth of an inch, but as the iron melts by the heat of the arc, this method cannot be used. The authors find that tungsten will stand the heat of the arc so that a lamp can be made on this principle. The tungsten glows highly by the heat and gives a strong light, but it does not appear to be consumed, so that the lamp has a long life. What is of interest is that such a tungsten lamp is very economical. At present their experimental lamp works on 12 volts, but it is probable that the voltage can be raised so as to bring it nearer what the usual lamps take, by using an inert gas under a higher pressure than is now employed. The new lamp gives a very white light.

Science Notes

A New Variety of Rubber in Borneo.—A new source of rubber is found in Borneo, according to a paper read on the subject before the Académie des Sciences, by Prof. Dybowski. It comes from the milk of a plant known as *Dycra costulata* and after coagulating, the milk forms a white gum known as jelutong. When quite dried, the matter is almost as hard as rosin, and it contains from 10 to 20 per cent rubber. It is said to be superior to the best Congo rubber. A factory has been recently put in operation and is now turning out a considerable amount.

Berlin University Improvements.—At the Berlin University some $200,000 has been expended for different improvements in the buildings, especially for the new auditorium. The observatory of the university is to be installed at Babelsberg near Potsdam, and the work on this building is already begun. At the Jena University a new building is being erected which will be devoted to anatomo-pathology, and it will be under the direction of Prof. H. Kionka. The Krupp company has made a considerable donation to Prof. Weichert of the Göttingen University in order to carry on aerodynamic experiments, and another to the astronomer Ambronn for constructing a star photographic instrument of a new design.

Adhesivity.—Harriot has reported to the French Academy of Sciences the discovery of a singular phenomenon which he calls adhesivity. When two sheets of brown gold are heated, in contact with each other, to the temperature at which they become converted into ordinary yellow gold, they remain firmly attached to each other. There is no action at a distance; actual contact is required to produce the adhesion. Hence the phenomenon cannot be due to electric or magnetic action. Nor can it be due to welding caused by the softening of the metal by heat, for contact produces adhesion some time after the two sheets of metal have become cold and brittle. Yet adhesion is not produced by the contact of two previously unheated pieces of brown gold, or yellow gold. A sheet of brown gold, heated to its temperature of transformation, does not adhere to a sheet which has been heated and cooled several days previously. The adhesion is very strong when the temperature of the hot sheet is between 570 and 660 deg. F.

Medicinal Plants.—The researches presented by Prof. Bourquelot to the Paris Academy of Medicine appear to show that the medicinal qualities of plants are greatly modified by drying them for use, and this action is much greater than may be supposed. The chemical as well as therapeutic qualities are found to be changed by the drying. Considerable experimental work was done in order to bring out these facts, and it is shown that when the plant is dried there is an inter-action of the various bodies it contains so that some of these destroy others, and in this way many of the active principles of the plants are destroyed or made insoluble. However, it is of interest to note that this action can be avoided, or at least in part. By rapidly sterilizing the plants, by dipping them in strong alcohol at the boiling point, the author was able to prevent any further destruction of the soluble ferments. Owing to this method, he could separate out the chemical principles which existed in the living plant and thus have a great advance in analysis of vegetable substances which is always a difficult matter. He also prepared new pharmaceutical substances which will be likely to give very good results for medicinal purposes. It will be seen that these results are far-reaching and may be very valuable.

Frozen Fruit.—The chemical changes produced in fruit by freezing and thawing have been investigated by Otto and Kooper. For example, analyses were made of ripe sloes and of the same fruit which had been kept 4 days after 5 hours exposure to a temperature of 23 to 25 deg. F. The loss of weight, chiefly water, was found to be 13.6 percent. The proportion of acids decreased from 9.18 to 6.57 per cent, and the tannin from 9.45 to 6.82 per cent, while the proportion of sugar increased from 30.48 to 31.75 per cent, and part of the glucose was converted into the sweeter fructose, or fruit sugar. The decrease in tannin is probably due to oxidation, by which the tannin is converted into red and brown substances, designated as "pholobaptenes." The fruit lost much of its astringency and acquired an agreeable subacid flavor. In medlars which had been frozen and kept 8 days after thawing the sugar decreased from 41.13 to 37.37 per cent, the acids from 4.36 to 3.50 per cent, and the nitrogen from 3.08 to 2.68 per cent. In Japanese quinces, kept 18 days after freezing and thawing, the sugar decreased from 16.91 to 7.60 per cent, the acids from 24.11 to 12.71 per cent, and the tannin from 3.82 to 1.84 per cent.

Engineering Notes

A New Railroad Across Persia.—According to the most recent information, the Russian government has approved the project for the Trans-Iranian railroad. The cabinet decided upon the construction of a railroading which is to connect Baku in south Russia with India across Persia, and this line will compete with the railroad which runs from Bagdad to the Persian gulf. An international company is to build the railroad.

A New System for Purifying St. Petersburg Water.—The city of St. Petersburg has had trouble with bad water from the Neva, but is soon to start an ozone purifying plant which appears to be the largest in Europe. It handles 60,000 cubic yards of water per day, and is installed by the Russian Siemens-Schuckert electrical firm. The system used here is stated to be a combination of the Siemens electric ozoning apparatus together with sterilizing towers designed by the Paris Ozone Company.

Grain Silos.—Large grain silos have been erected at Bremen at the Mühe establishment. They are entirely of metallic construction and use 24 cylindrical chambers of sheet steel having 17 feet diameter and 95 feet height, taking 12,000 tons of grain. This gives a very high pressure on the ground, so that the constructors use a large foundation bed of reinforced concrete. A bottom plate is first laid, and this upholds 42 columns of about 4 feet square section. Upon this is placed a reinforced concrete planking in order to receive the silos. The space between the columns is used to house various apparatus for transporting the grain.

A Canal from the Rhine to the Weser.—An extensive piece of work to be carried out in Germany will provide a continuous canal from the Rhine to the Weser. The first section is a canal which will lead from the Rhine so as to connect with the Dortmund-Ems canal, then the boats will follow this latter. A new section then branches off and crosses the Weser stream at Minden, ending at Hanover. In order to increase the flow from the Weser into the present canals there is building a barrage at Waldeck across the Eder valley, and thus a basin will be formed which is one of the largest in Europe, containing 210,000,000 cubic yards. The barrage is about 140 feet in height. It is expected to finish the present work in 1913.

Peculiarities of Submarines.—Equilibrium is almost as difficult to maintain for a submarine vessel as for an aeroplane. With modern large submarines, it is contended, the act of diving is performed when the vessels have headway. The bow is depressed by horizontal rudders controlled by skilled men, and the vessel moves obliquely downward. The desired depth having been attained, the steersman must so manage the horizontal rudders that the vessel shall practically maintain its level, but, in fact, its course becomes really an undulating one, up and down. There must be no movements of men or weights in the vessel without immediate compensation to restore and maintain the balance, else the submarine may dive to a disastrous depth. Manual has been found better than automatic control.

Locomotives Indicating National Character.—An ingenious French study of the various types of locomotives in use throughout the word, undertaken from a new point of view, presents some interesting conclusions. One of the most surprising inferences drawn was that genuine art is exhibited in the construction of locomotives. They show, it is contended from the French standpoint, beauty of line and proportion and true originality of treatment. The American locomotive combines elegance, practicality, convenience and power, thus betokening qualities of the race that does its work well. The English locomotive, it is stated, is more trim and snug, being smaller, but without loss of power. The French is lighter and finer in line than either of the two mentioned, but is less powerful and effective.

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